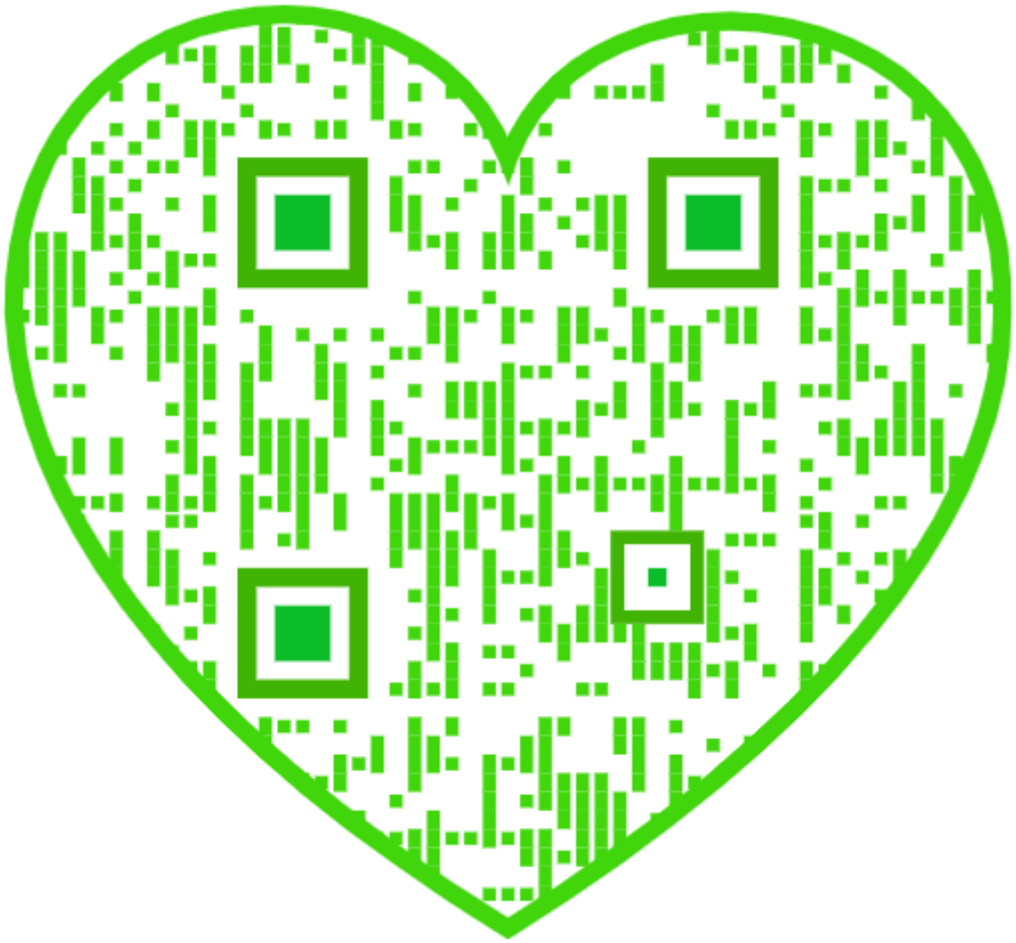

GLASS VASE.

Exhumed at Pompeii, in 1839, and preserved in the Museum at Naples.

J. B. Sibbald sc.

John Strudwick. del.

CURIOSITIES

OF

GLASS MAKING:

WITH

DETAILS OF THE PROCESSES AND PRODUCTIONS OF ANCIENT AND MODERN ORNAMENTAL GLASS MANUFACTURE.

BY

APSLEY PELLATT.

LONDON:
DAVID BOGUE, 86, FLEET STREET.
MDCCCXLIX.

ADVERTISEMENT.

THE following brief Treatise originated in the "LECTURES UPON THE MANUFACTURE OF FLINT GLASS, AND THE CURIOSITIES OF GLASS-MAKING," which I have had the honour to deliver at the Royal Institution.

In collecting materials for this Lecture, I found it desirable to examine a variety of evidences of the antiquity of the Art of GLASS-MAKING, when I at once became impressed with the interest and importance of such memorials in illustrating the history and progress of the invention. Among such treasures I number the exhumed relics in the British Museum, and similar depositories of Art upon the Continent. In the former truly national establishment, and more especially in the private specimens of ancient glass, under the care of Mr. Doubleday, and the curator of the Medal Department of the British Museum, I acquired invaluable aid in my researches. It also affords me much pleasure to acknowledge my obligation to the Marquis of Northampton, Mrs. Richardson Aldjo and Mr. Aldjo, Mr. Charles Roach Smith, Mr. Hamilton,

and other eminent collectors, for access to their specimens, which has afforded me facilities for arriving at the conclusions, historical, chemical, and manipulatory, now submitted to the Reader.

Such Facts and Curiosities in the History of Glass as have come to my knowledge of late years, I have engrafted upon my former Memoir "On the Origin, Progress, and Improvement of Glass Manufacture," published many years ago, but long since out of print; and this constitutes the First Section of the present Treatise. The Second Section treats of the Constituents and Manufacture of Glass, or in other words, of Practical Glass-making. And in the Third Section are described and illustrated the various Manipulatory Processes of the Art, more in detail than are to be found in any work on Glass-making, ancient or modern, British or foreign. The practical illustrations consist of working diagrams, drawn in the Glass-house; besides a very attractive Series of representations in colours, of Antique and Mediæval Specimens, including some of the Curiosities of Egyptian, Roman, Chinese, and Venetian Glass-making; and unquestionably possessing highly artistic beauty, as well as evidence of ingenious manufacture.

It may be observed that the literature of the ancients and middle ages affords but meagre information upon

the chemistry of colours, or other constituents of Glass; and still less upon the modes of blowing, shaping, or moulding, this artistic manufacture. One of the chief objects of the present work is to supply this defect, by concentrating within a practical focus the rays of information to be found in the works of Neri, Merrett, Kunkell, Blancourt, Loisel, Deaudenart, Bontemps, and others; and to blend with their researches certain Curiosities of Glass Manufacture, familiar to those practically engaged in Glass Works, but comparatively little known to amateurs of the Art, and those who take interest in its very elaborate details; this portion of the present volume being the result of my own experience and investigation.

The value of researches into the skill of by-gone ages in order to benefit the arts of our own time—more especially with the powerful aid of the present state of chemical science —is strikingly illustrated in Glass Manufacture. But for the existence of the Portland and Naples Vases, part of an ancient Vase in the possession of Mrs. Aldjo, and some interesting fragments from the ruins of Thebes, Pompeii, Rome, and Roman London, we should have been unacquainted with the high art of ancient Glass Cameo Engraving; and many Glass colouring constituents and manipulatory processes which now excite our admiration and imitation.

It is hoped that the present work, besides being acceptable to the Collectors of the Curiosities of Glass-making, may also be welcomed by the Encouragers and Patrons of Art, and Promoters of Science and Manufactures in general, to whom these pages are respectfully dedicated,

By their obedient and devoted Servant,

APSLEY PELLATT.

Falcon Glass Works,
Holland Street, Southwark.

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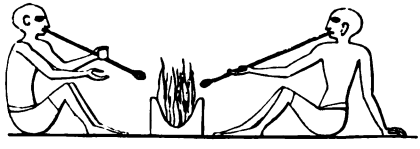
CURIOSITIES OF GLASS-MAKING.



(Egyptian Glass-blowers. Page 3.)

Historical Notices.

In the whole range of human invention, it would be difficult to point to a more ingenious or interesting result than the Manufacture of Glass. "Although perfectly transparent itself," says a popular illustrator of its history, "not one of the materials of which it is made, partakes of that quality;" a combination, which may, at the period of its invention, have been as astounding as the identity of charcoal and the diamond, established by the chemical philosopher of our time.

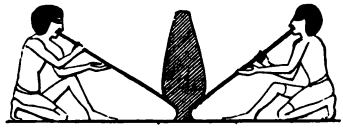
The art of making Glass is reputed to have been discovered by accident. This inference is strengthened by the fact, that it is scarcely possible to excite a fire of sufficient heat for metallurgical operation without vitrifying part of the bricks or stones of the furnace. Of such imperfect vitrification, the "Glass" occasionally dug up on the sites of buildings destroyed by great conflagrations, is a specimen.

To the Phœnicians was long ascribed the good fortune of the discovery. It is stated by Pliny, (*Nat. Hist.* lib. xxvi. c. 26,) "that some mariners, who had a cargo of *nitrum*, (salt, or, as some have supposed, soda,) on board, having landed on the banks of the river Belus, a small stream, at the base of Mount Carmel, in Palestine; and finding no stones to rest their pots on, they placed under them some masses of nitrum, which being fused by the heat, with the sand of the river, produced a liquid and transparent stream: such was the origin of Glass." However this may have been, the sand which lay for about half a mile round the river, was peculiarly well adapted for the making of Glass. The Sidonians, in whose vicinity the discovery was made, took it up, and in process of time, carried the art to a high degree of excellence; they are even said to have invented Glass mirrors. It is, however, a curious fact in the history of discovery, that the manufacture of Glass was, a few years since, unknown at Sidon, where it is reputed to have been first invented.

The above account by Pliny is, in substance, corroborated by Strabo, (xvi. 15,) and by Josephus, (*De Bell. Jud.* ii. 9.) Notwithstanding this explicit statement, it was long asserted that the ancients were unacquainted with Glass, properly so called; nor did the denial entirely disappear, even when Pompeii presented evidences of the skill of the ancients in Glass-making.

Our minute knowledge of Egypt, has, however, proved Glass-working to have been known by the Egyptians, at a very early period of their national existence. Sir J. G. Wilkinson, in his able work on the *Manners and Customs of the Ancient Egyptians*, has adduced three distinct proofs that the art of

Glass-working was practised in Egypt before the Exodus of the children of Israel from that land, three thousand five hundred years ago. At Beni Hassan, are two paintings, representing Glass-blowers at work (*see* p. 1); and from the hieroglyphics accompanying them, they are shown to have been executed



in the reign of the first Osirtasen, at the early date above mentioned. In the same age, images of *glazed* pottery were common; proving the mode of fusing, and the proper proportions of the ingredients for making Glass, to have been then known. Lastly, Sir J. G. Wilkinson adduces the instance of a glass bead, about three-quarters of an inch in diameter, and of the same specific gravity as our crown Glass: this relic Captain Hervey found at Thebes, and its date is proved by its bearing, in hieroglyphic characters, the name of a monarch who lived fifteen hundred years before Christ.* Such was the skill of the Egyptians in Glass-making, that they successfully counterfeited the amethyst and other precious stones worn as ornaments for the person. Winckelmann, a high authority, is of opinion that Glass was employed more frequently in ancient than in modern times: it was used by the Egyptians even for coffins;† they also employed it not only for drinking vessels, but for Mosaic work, the figures of deities, and sacred emblems, in which they attained excellent workmanship, and surprising brilliancy of colour.

It would be justifiable to suppose that the Hebrews brought

* See, in Plate No. 2, the specimens from Thebes.

† Within the year 1847, a process was patented in England for making Coffins of Glass.

Glass, and a knowledge how to manufacture it, with them out of Egypt, were not the evidence of history so explicit that it was actually discovered and wrought at their own doors. Whether it was used by them for mirrors is another question. That Glass, however, was known to the Hebrews appears beyond a doubt. (Dr. Kitto's *Cyclopædia of Biblical Literature;* art. *Glass.*)

Notwithstanding so many records exist of the knowledge of Glass-making possessed by the ancients, there remain but comparatively few specimens of antiquity to prove the fact. Most writers have erroneously referred to the beads, which ornament mummies, as satisfactory evidence of Egyptian Glass-making: the majority of these, however, are composed, not of Glass, but of burnt clay, or earthenware *glazed;* or, perhaps, of glazed earthenware pounded, and mixed with coloured Glass, fused together; of such substances are the numerous small images of mummies, beetles, and other figures. There can, however, be but little doubt that the Egyptians were well acquainted with the materials for making Glass, as well as with the chemical properties of the metallic oxides for colouring it; since, among the tombs at Thebes have lately been discovered small solid pieces of Glass, of a turquoise colour, which are reasonably supposed to have been used for the glazing of the earthenware beads and figures.

Fragments of blue, white, yellow, and green Glass, have likewise been found; but these may possibly have been made by the Greeks and Romans, who successively conquered Egypt; or, such specimens may have been procured from neighbouring or distant nations. One of these fragments is flat and of a circular form, resembling a coin; it is nearly entire, of an amber colour, and has a well executed figure of a

lion impressed upon it in bas-relief. Another specimen is of a green hue, and bears Arabic characters. The former is of the size of a sixpence; the latter is as large as a half-crown piece. Other specimens have been placed in our hands by Mr. Bankes, the traveller in Egypt; and of these we have introduced a coloured Plate, with a detailed description. The beauty, variety, and arrangement of colours, not only place ancient Glass manufactures high in our estimation as to taste and design, but the knowledge of the chemical art in opaque and transparent colouring which they evince, deserves to be appreciated, particularly their blues, without cobalt or nickel, and their reds without gold.* It was, however, formerly doubted whether the makers of these specimens were aware of the use of lead as a solvent of white Glass. (*See* page 7.)

It is certain that the Glass-houses of Alexandria were celebrated among the ancients for the skill and ingenuity of their workmen; and from thence, the Romans, who did not acquire a knowledge of the art till a later period, procured all their Glass-ware. Most of the large, greenish Glass cinerary vases in the British Museum, found in Roman barrows which contained bones and bone-ashes, are, probably, the production of extensive Egyptian or Roman works: they are large, and of excellent form and workmanship: but the Glass is somewhat impure, of a greenish tint, has numerous globules and *striæ* (*see* PLATE), and is not unlike the modern common crown or sheet Glass in quality.† Strabo relates, that a Glass-maker of Alexandria informed him, that an earth, (pro-

* See Klaproth's analysis.

† Although remains of ancient Roman Potteries have been exhumed in Great Britain, it does not appear that any traces of subterranean Glass-houses or works have been discovered.

bably manganese,) was found in Egypt, without which, the valuable coloured glass could not be made. It is also related that the Emperor Hadrian received as a present from an Egyptian priest, several Glass cups, sparkling with every colour; these, as costly wares, were ordered to be used only on grand festivals.

We have incidentally mentioned the discovery of Glass at Pompeii. Glass vessels have, also, been found among the ruins of Herculaneum; and it appears that Glass was used for admitting light to dwellings in Pompeii,* although other houses had window-frames filled with a kind of transparent talc.†

In the reign of Tiberius, a Roman artist had, according to Pliny, his house demolished—according to other writers, he was beheaded—for making Glass malleable. The Pompeian and Roman architects are known to have used Glass in their Mosaic decorations; of these, remains have been found among the ruins of the villa of the Emperor Tiberius, in the island of Capri. Several specimens, also, are yet to be seen in Westminster Abbey, cemented into the sides of the tomb of Edward the Confessor. They are flat pieces, about a quarter of an inch thick; the under layer has a reddish, granulated appearance,

* Mr. Auldjo, of Noel House, Kensington, who resided several years at Naples, states, that he has seen Glass in the window-frames of some of the houses of Pompeii. Mr. Roach Smith has a specimen of ancient flat Glass; such as he believes to have been used by the Romans, or their predecessors, for windows.

† Glass, melted and cast into plates, is said by St. Jerome to have been used in his time, (A.D. 422,) to form windows. About a century later, Paulus Silentiarius mentions the windows of the church of St. Sophia, at Constantinople, which were covered with glass; and from this period, frequent allusions to the similar use of glass are met with in various authors.—*Treatise on Glass: Cabinet Cyclopædia.*

and is perfectly opaque; whilst the upper surface is of white transparent glass. Between the two, is a very thin layer of gold-leaf—the whole being fused into one substance. This description of gilded Glass was, no doubt, highly valued; and the perfect state in which it is found, affords a convincing proof that the art of Glass incrustation was, to a certain extent, known to the ancients. The pieces which have hitherto been met with are, for the most part, about an inch square, or of the same size in a diamond form.

During the reign of Nero, great improvements were made in Roman Glass. The perfectly clear Glass, which bore the nearest resemblance to crystal, was so highly valued, that Nero is stated to have given for two cups, of no extraordinary size, with two handles, 6000 sestertia, or nearly £50,000 sterling. The superior kinds of Glass were in such extensive use, in the time of Pliny, as to have almost superseded cups of gold and silver. Hence, the manufacture would appear to have been confined chiefly to articles of luxury—such as vessels of glass to imitate precious stones, intended for cutting by the lathe, by Roman artists, or Grecian artists resident in Rome, in the style of cameos in relief. In the British Museum are preserved many specimens of fragments of vases, and small pieces of white opaque enamel Glass, upon blue and amethyst transparent grounds, supporting the probability of this opinion. White crystal Glass, without lead, cut to imitate rock-crystal, was then known; although the introduction of lead into white glass was, till recently, considered to be of British origin.* (*See* PLATE 3, fig. 3.)

* A few pieces of white cut Glass, of Roman manufacture, have been found, without lead; their specific gravity being only 2.049, whereas Flint-

A few small specimens of Roman Glass have been preserved in the British Museum. One of them was of an octagon form, of light azure blue, which crumbled to fragments on being exposed to the air and light; it had a dull appearance, and the crumbling of the particles without friction, was caused by an excess of alkali, gradually exuding for many years, until the cohesion of the crystals was destroyed. Trade secrets in the preparation of Glass for gems* most likely existed in ancient times; for very little has been written by Egyptian, Greek, or Roman authors on the chemical constituents of Glass gems, or cameo-engraved vases. Glass in solid pieces, such as gems and mosaics, was, probably, manufactured in small Glass-houses; and the secrets of the processes may have passed from father to son for several successive generations. The Glass-makers of Rome had a street assigned them in the first region of the city. A tax was, also, laid upon them by Alexander Severus, which existed in the time of Aurelius, and probably long after.†

Glass-making in Britain is supposed to be of very ancient date; if the opinion of Pennant be well founded, of a period prior to the Norman Conquest. The art of manufacturing Glass into such ornaments as beads and annulets, was certainly known to the Druids; and Glass vessels were made by the Anglo-Saxons.‡

Glass of the usual density, is about 3.200 to 1.000 of water. Subsequently, other pieces of Glass have been exhumed in the city of London; these are considered, by Mr. Roach Smith, to be ancient Roman; one small piece is of 2.600, and another 3.144, specific gravity. (See remarks in the after part of this work.)

* See Plate 6, fig. 6.

† A sort of ancient excise, highly injurious to industrial art, and, probably, one of the causes that transferred the Glass manufacture to Venice.

‡ See sketch and description of an Anglo-Saxon vase, in No. 8, page 347, of the *Journal of the British Archæological Association.*

Near Alberfraer Palace, in Wales, have frequently been found the *Glain Neidyr*, or Druid Holy Snakes. Of these, the vulgar opinion was,* that they were produced by snakes joining their heads together, and hissing; that by such means, a kind of bubble like a ring was formed round the head of one of them, which the rest, by continual hissing, blew on till it came off at the tail, when it immediately hardened into a ring. Whoever found one of these "snake-stones," was to prosper in all his undertakings. Such Glass annulets are generally about half as wide as our finger-rings, but much thicker. They are usually of a green colour; but, some are blue, and others are curiously variegated with waves of blue, red, and white. They are, in fact, beads of Glass, which were used by the Druids as a charm to impose upon the vulgar.—(*See page* 12.)

Dr. Stukeley gives an account of a curious Glass vase, found near a body that was dug up at Chatteris, in the Isle of Ely: its exact figure, unfortunately, could not be ascertained, as it was broken; but Dr. Stukeley remarks: "What, I believe, our present Glass-makers cannot perform, many pipes proceeded from it but closed; I think ten in number. I never saw one like it, nor can I conjecture what its purpose was."

Camden records: "On the commons about Winstre, are several barrows: in the largest were found two Glass vessels, between eight and ten inches high, with wide round mouths, containing about a pint of clear, greenish water; also, red Glass beads, and other ornaments and trinkets."†

Mr. C. Roach Smith, Secretary to the Archæological Asso-

* Camden's *Britannia*, vol. ii. p. 750. An account of this *anguinum ovum*, or serpents' egg, is given by Pliny—*Nat. Hist.* lib. xxix. c. 3.

† Camden's *Britannia*, vol. ii. p. 311, Derbyshire.

ciation, possesses several of these beads. This indefatigable antiquary has, likewise, some fragments of Roman Glass, dug up in the city of London; they have projecting pillars outside, while the interior is not indented, but smooth; these pillars have been formed, partly by moulding, and partly by rapid rotation, increasing the projection on the principle of centrifugal force: the remainder are portions of a vase-shaped basin of elegant form. (*See* PLATE 3, figs. 1, 2.) Several other Roman specimens of this kind are to be seen in the Museum at Boulogne-sur-Mer. English Glass-makers, until this discovery, considered the patent pillar, (as it is called,) to be a modern invention. A Roman vase thus made is to be seen entire at the Polytechnic Institution, in Regent-street; it is a complete specimen of pillar moulding, but the pillars are very much less in width and projection than some of those at Boulogne, and in Mr. Roach Smith's collection. (*See* PLATE 5, fig. 2.)

The Aggry beads of Ashantee, as involving points of manufacture analogous with the above specimens, may be noted here. Mr. Bowdich, during his visit to that country, procured some of these Aggry beads, which the natives invariably declare to be "found in the Dinkira, Akim, Warsaw, Ashanta, and Fantee countries, the greatest number in the former, being the richer in gold. They say they are directed to dig for them, by a spiral vapour issuing from the ground, and that they rarely lie near the surface. Those of inferior beauty frequently fetch a large price, from having been worn by some royal or eminent character." Dr. Leyden describes the "Aigris, a stone of a greenish blue colour, supposed to be a species of jasper, small perforated pieces of which are valued at their weight in gold, and stated to be used as for money."

Dr. Leyden, however, considers this to refer to the Popo

bead; though that is semi-transparent, of a bright blue, resembling cornelian, (which is frequently found in these countries,) and said to be obtained in the same manner as the Aggry bead. Isert describes them "as a sort of coral, with inlaid work." "The art of making beads," (says Mr. Bowdich,) "is entirely lost, or was never known in these parts. It is not "improbable that, in the golden age of Egypt, she had com- "munication with the Gold Coast; indeed, it has been thought, "and perhaps not without some reason, that the Gold Coast is "the Ophir of Solomon.* The variegated strata of the Aggry "beads are so firmly united, and so imperceptibly blended, that "the perfection seems superior to art: some resemble Mosaic "work; the surfaces of others are covered with flowers and re- "gular patterns, so very minute, and the shades so delicately "softened one into the other, and into the ground of the bead, "that nothing but the finest touch of the pencil could equal "them. The agatized parts disclose flowers and patterns, deep "in the body of the bead; and thin shafts of opaque colours, "running from the centre to the surface. The natives pretend "that imitations are made in the country, which they call boiled "beads, alleging that they are broken Aggry beads, ground into "powder and boiled together, and that they know them because "they are heavier; but this I find to be mere conjecture among "themselves, unsupported by anything like observation or dis- "covery. The natives believe that, by burying the Aggry beads "in sand, they not only grow but breed. The colouring matter "of the blue beads has been proved by experiment to be iron; "that of the yellow, without doubt, is lead and antimony, with "a trifling quantity of copper, though not essential to the pro-

* See Plate 2, figs. 8 to 15.

" duction of the colour. The generality of these beads appear " to be produced, from being coloured in thin layers, afterwards " twisted together in a spiral form, and then cut across; also " from different coloured clays raked together without blending; " how the flowers and patterns in the body, and on the surface " of the rarer beads, have been produced, cannot be so well ex- " plained. Besides the suite deposited in the British Museum, " I had the pleasure of presenting one of the most interesting " kind to Baron Humboldt; and I have also sent one to Sir " Richard Hoare, as it seemed to correspond so closely with the " bead which he found in one of the barrows, and describes as " follows, in his *History of Wiltshire*:—'The notion of the " rare virtues of the *Glain Neidyr*, as well as of the continued " good fortune of the finder, accords exactly with the African " superstition. A large Glass bead, is of the same imperfect " petrifaction as the Pully beads, and resembles also, in matters, " little figures that are found with the mummies in Egypt, and " are to be seen in the British Museum. This very curious " bead has two circular lines, of opaque sky-blue and white, " and seems to represent a serpent entwined round a centre, " which is perforated. This was certainly one of the Glain " Neidyr of the Britons; derived from *Glain*, which is pure and " holy, and *Neidyr*, a snake.'"

Some interesting specimens of Roman and early British glass may be mentioned here. Not long since, there were sent to the Archæological Institute, a fragment of a glass vessel, supposed to be of Roman date, discovered at Lavenham, in Suffolk. In the central part was inclosed a small quantity of liquid, half filling the cavity; it was slightly tinged with a pinkish colour, and seemed to deposit a whitish sedi-

ment. The Glass was of a pure white crystalline texture. Stow relates that amongst numerous Roman remains found when the ancient field, called Lolesworth, now Spittlefield, was broken up, about the year 1576, to make bricks, "there were found divers phials, and other fashioned glasses, some most curiously wrought, and some of crystal, all which had water in them." Others had "oyle in them, very thick and earthly in savour." (*Survey of London*, b. ii. c. 5, p. 177, ed. 1633.) In the Museum of Antiquities, at Rouen, a small Glass vessel, accounted to be Roman, is preserved, hermetically sealed, and half full of liquid. (*Archæological Journal*, No. 9. March, 1846.)

Early in 1847, there were found, in digging at Cuddesden, the episcopal palace of the Bishop of Oxford, several human skeletons; and near them were two sword-blades, some bronze fragments, and two small glass vases. The latter are of a very pale blue transparent glass; the surface has become iridescent from decomposition, and this, in the larger one, gives it a streaked appearance. The larger vase is 3 inches deep, by $5\frac{7}{8}$ inches in diameter, and is ornamented on the sides with three waved lines touching at the projections; underneath is a figure, much resembling the cusping of a circular window. The other vase is $4\frac{3}{4}$ inches in diameter. The pattern on both is produced by thick threads of glass, applied to the surface while melted. These vessels are conjectured to be of the Saxon period, and to be of as early a date as the fifth or sixth century. Curious Glass vessels, apparently drinking-cups, have also been occasionally discovered, ornamented, like the Cuddesden vases, with threads of Glass, attached to their surface when in a molten state, forming

spiral, wavy, and zig-zag lines, in relief, or converging towards the centre of the bottom of the vase; a vessel shaped like a bell, was discovered in Minster church-yard, in the Isle of Thanet, placed on the skull of a skeleton, the mouth downwards; another, of very singular form, was found in a similar position, at Castle Eden, Durham; and a third, of conical shape, ornamented with spiral and wavy lines, in relief, was found, with human remains and weapons, at Denton, in Buckinghamshire. (*Archæological Journal*, No. 14, June, 1847.)

In 1846, there was exhibited to the Archæological Institute, an ancient bead, believed to have been found near Headington, Oxford. The substance of this bead appears almost black; but, when held to the light, it is found to be a beautifully clear deep green Glass; the surface of it is richly varied with splashes of white enamel, mixed with blue, radiating from the centre, and slightly contorted, particularly on the under side. The enamel penetrates some distance into the substance of the Glass, and appears to have been thrown on the mass, while in a soft state; it was then, probably, slightly twisted, and its globular form flattened between two plane surfaces. It is not perforated, and only slightly depressed in the centre.

Another bead, of similar character to the above, found in the bed of a stream, which flows near the British camp of Madmarston, is preserved in the Ashmolean Museum. Here, also, is a curious series of beads, which belonged to the original collection of Elias Ashmole, or to that added by Dr. Plot. Among them, is a bead similar to that above described, except that the body is not of fine green, but more like the common modern bottle-glass; the markings are of white and blue enamel. Here are, likewise, two imperforate beads, or

balls, one of smoke-coloured, and the other of light brown, Glass; and both ornamented with lines of white enamel radiating spirally from the centre. Among the perforated beads, are many curious varieties, and great diversity in the colour of the Glass; there are some entirely colourless, and others approach nearly to it. Some of the enamelled specimens are formed of concentric layers of different colours; and the facets are cut across these, and thus produce a variety of waved lines. Another has an imitation of stones of different colour, being set in studs on its surface; and a third is ornamented with small raised and twisted coral-work. Indeed, the whole collection, from the diversity in form, material, colour, and design, which it exhibits, is well deserving of a careful examination. (*Archæological Journal*, No. 12, December, 1846.)

Glass engraving in its modern acceptation—viz., roughed and polished in intaglio,—was probably unknown to the Romans and their predecessors. The art of cutting Glass in relief, was, however, known to them at very remote periods; for which purpose, as we learn from Pliny, (*Nat. Hist.* xxvii. c. 4,) the diamond was used.

The Chinese have long been skilled in Glass-making. M. Abel Rémusat states,* that their imitation of the precious stone Yeschm was so excellent, that it was almost impossible to distinguish the artificial from the real. This description of Glass-ware was manufactured into vases of various forms by the Chinese, from whom the Arabians procured them. Some were of a clear,

* Histoire de la Ville de Khotan, tirée des annales de la Chine, et traduite de la Chinois; suivie de recherches sur la substance minérale, appellée par les Chinois, Pierre de Ju, et sur le Jaspe des Anciens. Par M. Abel Rémusat, pp. 153 — 159.

transparent white, extremely brilliant, and as pure as a precious stone; and others of a beautiful blue, and equally pure. In Egypt and Syria, no difference was known between the real and artificial Yeschm, the latter being of the same form, thickness, and specific gravity as the former. It is even asserted, that in Cairo, and other cities, the artificial vases were as highly valued as those of the real Yeschm, and that enormous prices were given for them. The Chinese have also equally well imitated their Ju* stone, which was too costly for persons of moderate fortune. It is a coloured Glass of rich appearance, and greenish tint, and of such hardness and weight, that it frequently surpasses the real Ju. Fragments of it are often to be met with in the shops of the venders of curiosities, and some are erroneously denominated rice composition. A square solid pedestal of yellow tinged glass, of Chinese manufacture is preserved in the Museum of Economic Geology, in London: it is surmounted by a small lion, carved by the engraver's mandril tool, at the lathe, out of the upper part of the solid pedestal, at great labour and cost. (*See* PLATE 5, fig. 5.) This was, probably, made from English Glass, re-fused in China with an increased quantity of lead. Small coloured vases, figures, and almost every description of ornament sculptured in stone, have been imitated in opaque Glass, by the Chinese. A specimen of artificial Ju stone may be seen at the British Museum: it is of a bluish-white colour, resembling enamel, of an octangular form, and about the size of a snuff-box; it is extremely hard, and, in proportion to its size, of astonishing weight. Notwithstanding the Chinese pos-

* Histoire de la Ville, *ut ante*, p. 159.

sess a complete knowledge of the art of Glass-making, the manufacture of useful articles of Glass appears to be wholly neglected by them. It is even asserted, that they will not use the ordinary description of Glass, some of which they import from Europe; and, when broken, they re-melt, and convert it into such articles as they require; they also import broken flint Glass from Europe, for re-manufacture. The Emperor has a royal Glass manufactory in Pekin, which is carried on as much for amusement as for utility.

A most singular art of forming pictures with coloured Glass was practised by the ancients. It consisted in laying together fibres of Glass of various colours, fitted to each other with the utmost exactness, so that a section across the fibres represented the object to be painted; and was then cemented by fusion into a homogeneous, solid mass. In some specimens of this art which were discovered about the middle of the last century, the picture has on both sides a granular appearance, and seems to have been formed in the manner of Mosaic work; but the pieces have been so accurately united by intense heat, that, not even by means of a powerful magnifying Glass can the junctures be discovered. One small fragment, in the possession of Mr. Doubleday, at the British Museum, exhibits an arabesque border of various colours, the outlines of which are well decided, and sharp, and the colours pure and vivid; whilst, a brilliant effect has been obtained in another piece by the artist, employing in contrast, opaque and transparent Glasses. The pictures appear to be continued throughout the whole thickness of the specimen, as the reverses correspond in the minutest points to the face; so that, were the Glass to be cut transversely, the same arabesque border would be found

exhibited on every section. It is conjectured that this curious process was the first attempt of the ancients to preserve colours by fusing them into the internal part of the Glass. (*See* PLATE 3, figs. 6, 7, 8.)

In the British Museum are many of these interesting curiosities of Glass Mosaic work, some of perfectly white clear Glass in the form of leaves or flowers, interwoven in the midst of a dark green ground; the refraction of the latter upon the white edges of the flower pattern, producing an intermediate, blended effect. Most of the pieces are small, and some of the patterns very minute; but great study of effect, and much taste as well as skill, are apparent in their execution. There are also numbers of fragments of white enamel upon blue, and white upon amethyst grounds, of well executed designs in relief; probably, executed by eminent Roman or Grecian artists resident in Rome. (*See* PLATE 3, fig. 10) On precious stones becoming rare or expensive, artists had recourse to artificial gems; some of them were prepared with two or three layers of colours in opaque Glass welded to each other, of oval or round forms, to imitate real stones; and these crude pieces, when worked and ornamented by the lathe, enabled the gem engravers to meet the public demand at a comparatively small cost. Artists having thus become accustomed to work Glass in the manner of cameos, the execution of larger objects of taste—viz., vases like the Naples, and Portland—was comparatively easy.* (*See* PLATE 1.) A great

* Mrs. Richardson Auldjo has a fragment of a vase of Etruscan form, with carved handle and engraved bas-relief ornaments; the remainder of the fragments are in the British Museum. Minutelli has given a drawing of the entire vase; the foliage and bird engraving is in white enamel, upon a blue sapphire ground. This fragment was found in Pompeii, a few years since.

variety of phials and bottles, chiefly of an elongated shape, have been found among the subterranean ruins of Herculaneum. Most of these are of Glass of unequal thickness, of a green colour. A few vessels of cut white Glass have also been found, but they are of small dimensions.

In the British Museum, also, are a few large cinerary urns of green Glass, which are fine specimens of the ancient art of Glass-blowing. The round vases are of elegant forms, with covers and two double handles, the formation of which must convince any person capable of appreciating the difficulties which even the modern Glass-maker would have to surmount in executing similar handles, that the ancients were well acquainted with the art of making round Glass vessels.* (*See* PLATE 5, fig. 4.) Although their knowledge appears to have been extremely limited as respects the manufacture of square vessels, and more particularly oval, octagon, or pentagon forms, we meet with several crudely formed square vases, a great number of lachrymatories, and various fragments of other vessels, some of which have a raised border, hollowed inside, as if blown in open-and-shut metal moulds: there are, besides, small blue vases of very rich colours, variegated by yellowish white enamel patterns, &c.

The most celebrated ancient Glass vase is that which was, for more than two centuries, the principal ornament of the Barberini palace, and which is now known as the "Portland Vase."

* An elegant double-handled vase of light green Glass, nine inches high, and five inches in diameter, exhumed from Bourne Park, near Canterbury, no doubt of Roman or earlier manufacture, is described in the *Journal of the British Archæological Association*, No. 9, page 48. The handles show considerable manipulating skill.

It was found about the middle of the sixteenth century, enclosed in a marble sarcophagus, within a sepulchral chamber under the Monte del Grano, two miles and a half from Rome, on the road to Frascati. It is ornamented with white opaque figures in bas-relief, upon a dark blue transparent ground. The subject has not hitherto received a satisfactory elucidation; the design, and more especially the execution, are truly admirable. The whole of the blue ground, or at least the part below the upper welding of the handle, was originally covered with white enamel, out of which the figures have been sculptured, in the style of a cameo, with astonishing skill and labour.* Although there cannot exist any doubt as to the materials of which this vase is composed, it is extraordinary that notwithstanding four authors have agreed in considering it to be stone, all differ as to the *kind* of stone; Breval regarded it as calcedony; Bartoli, sardonyx; Count Tetzi, amethyst; and De la Chausse, agate. That travellers or authors should have been so ignorant, as to suppose that a natural production could have been hollowed out of the size of the Portland Vase seems surpassing strange; nor does it appear less perplexing that each account should differ in the colour and description of stone. The subject of the bas-relief is involved in equal mystery, for as much difference of opinion exists respecting it as of the materials. The fable of Thaddeus and Theseus was considered by some writers to be the subject; Bartoli supposed the group to represent Proserpine and Pluto; Count Tetzi, that it had reference to the birth of Alexander Severus, in whose supposed tomb it was discovered; while

* Fragments of high art in engraving have been found with as many as five layers of differently coloured Glasses. (See PLATE 5, fig. 1.)

Mr. Windus, F.S.A., the most recent illustrator, has asserted the design to be the pictorial representation of a lady of quality consulting Galen, who at length discovered her sickness to be that of love for a celebrated rope-dancer. The piece of bas-relief engraved Glass, forming the foot, is distinct, and cemented into the bottom of the vessel; it appears to be of later date than the body of the vase, and by a different artist; possibly, an accident in the making or engraving the vase might have compelled the artist to have the foot of a subsequent manufacture. It has been likewise conjectured that the neck of the vase being small, the large opening at the bottom gave more room for putting in ashes or bones, prior to the foot being finally cemented on. At all events, this beautiful ancient work of art affords satisfactory proof that the manufacture of Glass was carried to a state of high perfection by the ancients.*

Venice, during a long period, excelled all Europe in the

* An account of the Portland Vase was published by the late Mr. Wedgwood—the Father of the Potteries and an accomplished philosopher: it is, like its author, truthful and accurate. On this famed Vase being offered for sale, Wedgwood, considering that many persons to whom the original was unattainable, might be willing to pay a handsome price for a good imitation of it, endeavoured to purchase it, and for some time continued to offer an advance upon each bidding of the Duchess of Portland, until at length, his motive being ascertained, he was offered the loan of the vase on condition of withdrawing his opposition. Consequently, the Duchess became the purchaser at the price of eighteen hundred guineas. It is stated, that a limited number of copies were sold at fifty guineas each, and that the model cost five hundred guineas: probably, the celebrated Flaxman was the artist who was so liberally rewarded. Sir Joseph Banks and Sir Joshua Reynolds bore testimony to the excellent execution of these copies, which were chased by a steel rifle, after the bas relief had been wholly or partially fired.

fineness of its Glass. Judging from the curious specimens to be seen in this country, the Venetian Glass-blowers must have been artists of considerable skill. A Glass knife-handle, supposed to be their work, has an exterior coating of white transparent Glass, enclosing differently coloured Glass, fused into one variegated mass. The effect of these colours under the white Glass is very pleasing. The Venetian ball is a similar specimen of ingenuity. The exterior coating of white Glass is, in some specimens, much decomposed and defaced by time; but the beauty of the interior workmanship is easily restored by the usual mode of polishing Glass. (*See* PLATE 6, fig. 1.)

The Bohemians were formerly very celebrated for their extensive Glass-works. They imitated the Venetians in their curious method of ornamenting Glass-ware, which has since become well known, and was at one time much in repute in this country. In making the stems of wine-glasses and goblets, they enclosed white and coloured enamel tubes, twisted together with colourless transparent Glass. A most beautifully engraved vase by a Bohemian artist, is in the possession of the author; the workmanship is even more elaborate than that of the Portland Vase: the subject is from Le Brun's painting of the conquest and final overthrow of the Persians at the battle of Arbela, by Alexander the Great. For depth of workmanship and artistic execution, as a modern intaglio engraving, this vase is unrivalled.

In Howel's *Familiar Letters* we find some curious details of Venice, and her Glass-making celebrity. The first Letter, containing these records, is dated, "Venice, May 30, 1621," and states: "Among other little gentile ilands which attend

the cittie of Venice, ther is one called Murano, about the distance of a little mile, where crystall Glasses are made; and 'tis a rare sight to see a whole street where on the one side there are about twenty furnaces at work perpetually, both day and night. It hath bin observed and tryed, that if one shoed remove a furnace from Murano to Venice herself,—nay, to the other side of the street,—and use the same men, materialls, and fuell, and the same kind of furnace, ev'ry way, yet one cannot be able to make cristall Glasse in the same perfection, for bewty and lustre, as they do at Murano; and the cause they alledg is the qualitie and cleerness of the circumambient air which hangs ore the place, and favoureth the manufacture, which air is purified and attenuated by the concurrent heats of so many furnaces together, which never extinguish, but are like the vestal fyres that allwayes burn."

In another Letter, dated " Venice, the 1st of June, 1621," we find: " The art of Glasse-making is very highly valued in Venice; for whosoever comes to be a master of that profession is reputed a gentleman *ipsâ arte*, for the art's sake: and it is not without reason, it being a rare kind of knowledge and chymistry to transmute the dull bodies of dust and sand, for they are the only main ingredients, to such a diaphanous, pellucid, dainty body, as we see cristall Glasse is, which hath this property above gold and silver, or any other mineral to endure no poyson. Glasse allso hath this rare qualitie, that it never loseth anything of its first substance and weight, though us'd never so frequently and so long. It is wonderfull to see what diversitie of shapes and strange formes those curious artists will make in Glasse, as I saw a complete gallie, with all her masts, sayles, cables, tackling,

prow, poope, forecastle, anchors, with thee long-boat, all made out in cristall Glasse, as allso a man in armor."

Thus, we see that a whole street of Glass-houses was then in existence, and in full reputation and employment. Much mystery was, however, current, either suggested by policy, narrow-minded selfishness, or superstition, as to the cause of the excellence of the Venetian Glass, which by Howel was ridiculously attributed to "Venice air." Its white Glass may, then, have been appreciated; but it is far inferior in pellucid refractibility to modern English crystal Glass. The finest pieces of ancient Venetian Glass-ware are rather celebrated for lightness than crystalline beauty: it is excellent, considering that lead forms no part of its composition.

Venice Glass was, however, in high repute in England in Howel's time; for, in another of his Letters, dated "Westminster, 15 Jan., 1635," we find the author thus writing "to Mr. T. Lucy, in Venice:" "My Lady Miller commends her kindly unto you, and she desires you to send her a compleat cupboard of the best crystall Glasses Murano can afford, by the next shipping." Drinking Glasses made at Venice were also about this time believed, by credulous persons, to have the property of breaking when a poisonous liquid was poured into them—an absurd belief referable to exaggeration of the celebrity of the manufacture. This alleged detective property is thus referred to by Sir Thomas Browne, in his work on *Vulgar Errors:* "Though it be said that poison will break a Venice glass, yet have we not met any of that nature."

The Venetians, also, originated the modern style of Glass-engraving which afterwards extended through all the Glass-making countries in Europe. The first specimen was scratched

with a diamond, or broken steel file; but the engravings produced by copper and lead wheels at the lathe are far superior. With few exceptions, the design was a roughed surface *intaglio*, which, contrasted with its white transparent ground, had a lace-like delicacy of effect; especially if improved by traced polished lines, occasionally introduced, to give the relief of light and shade. The Venetians not only revived the curious ancient art of forming Mosaic Glass pictures, but introduced many other ingenious novelties. In the present day, Venice is unrivalled for its cheap and excellent Glass bugles and beads, of which enormous quantities are sold for the African and other foreign markets.

The Venetians and Bohemians had cylindrical drinking Glasses curiously painted in vitrified colours, with coats of arms, called *vidre come*. The ancient painted Glass vase, commemorated in the old ballad of the "Luck of Muncaster," was, probably, of early Bohemian manufacture.* It has also been the subject of a poetic romance.

In addition to their ordinary window and other Glasses, the Venetians were celebrated for the following ingenious Glasses, which, with the exception of the *vitro di trino* and frosted, were imitations of the ancient manufacture. (PLATE 4, figs. 1, 2.)

The filigree, which consists of spirally-twisted white and coloured enamel Glasses, cased in transparent Glass, was much used by the Venetians for the stems of wine-glasses, goblets, &c.; and, when placed together, side by side, in alternate colours, it was manufactured into tazzas, vases, and other ornamental articles. Millefiore Glass consists of a great

* The different Glass-works of Bohemia are stated, at this day, to afford subsistence to more than 30,000 persons.

variety of ends of fancy-coloured tubes, cut sectionally, at right angles with the filigree cone, to form small lozenges or tablets; and these, when placed side by side, and massed together by transparent Glass, have the appearance of an innumerable series of flowers or rosettes, for ornamental vases, tazzas, &c. (*See* PLATE 6, fig. 2.) Mosaic Glass, as manufactured by the Romans and Venetians, was produced by threads or small canes of variously coloured opaque or transparent Glass, of uniform lengths, ranged sectionally together in large masses, or in small quantities, so that the ends shall form grounds, on which are patterns of flowers, arabesques, or any Mosaic designs; and these being cut transversely, obtusely, or at right angles, form slabs of any required number and thickness, the same pattern being repeated at every cutting. Smetz Glass is produced by fused lumps of coloured Glass, rolled one colour into another, so as to imitate cornelian and other stones. *Vitro di trino* is fine lace-work, with intersecting lines of white enamel or transparent Glass, forming a series of diamond-shaped sections; the centre of each has an air-bubble of uniform size, executed almost with the precision of engine lathe-turning. The frosted Glass will be described in a subsequent part of this work. The Bohemians followed the Venetians, and imitated most of these curious proceeds of the Glass furnace.

Glass was first used by the Italians for the purpose of making cameos and intaglios, by impressing it while warm into a mould of tripoli; the Glass being sometimes backed with plaster of Paris. Foreigners visiting Italy are thus supplied with copies of antique gems for the formation of cabinet collections. They seldom exceed, however, an inch

in diameter, and perhaps could not be made much larger. The manufacture of these small artificial gems has been very successfully carried on by Mr. Tassie, of Leicester-square, whose collection is extensive and valuable.

The first English Glass-houses for the manufacture of fine Glass were those of the Savoy and Crutched Friars, established about the middle of the sixteenth century.* It appears, however, that the English manufactures were for a considerable time much inferior to the Venetian; for, in 1635, nearly a hundred years later, Sir Robert Mansel obtained a monopoly for importing the fine Venetian drinking-glasses. The art of making these vessels was not brought to perfection in this country till the reign of William III. Our Glass-manufacture has since made rapid progress; and the white crystal Glass-works of England indisputably excel, at this moment, those of any other country.

The essential and distinguishing qualities of good Glass are, its freedom from specks or striæ, and its near resemblance to real crystal in its brilliant, pellucid, refractive, and colourless transparency. In all these respects, the productions of the British Glass-houses are at present unrivalled. It only remained

* "The Friars' Hall was converted into a Glass-house for making drinking vessels, which, with forty thousand billets of wood, were destroyed by fire in 1575. (*Stow's Survaie*, 293.) The manufacture was set up in 1557, and was the first of the kind known in England. I may add here, that the finest flint Glass was first made at the Savoy; and the first plates for looking-glasses and coach-windows, in 1673, at Lambeth, under the patronage of George Villiers, Duke of Buckingham."—*Pennant's* "*London*," 5th edit., p. 377.

Probably these works, either by the use of wood fuel, or some other cause, were not remunerative; and therefore were not rebuilt at the Savoy, or elsewhere.

for them to evince their superiority in the ornamental branches of the art; and this has been partially accomplished by the improved taste of the public, compelling manufacturers to employ superior artists; as well as by the encouragement given by Government in establishing Schools of Design for instruction in classic design and correct drawing.

The ancients were not altogether ignorant of the art of embodying ornament in the interior of Glass; but their productions were only partially enclosed. The picture of a duck, described by Winckelmann, or the arabesque Mosaic in the British Museum, is but a partial incrustation; as the painting is neither completely enclosed, nor protected from the air. The Venetian ball and the Bohemian ornamental stems are perfect incrustations; but they are curious, rather than tastefully designed, or useful. It was impossible to introduce into the interior of Glass any device or figure, which could be with certainty accurately defined; because, the variegated Glass in the interior being of the same nature as the enamel, is (especially if opaque) fusible at a less degree of heat than the coating of white transparent Glass: consequently, any impression must have been effaced, when, in the process of manufacture, it became incased in the hot transparent Glass. To render the art of incrustation subservient to any useful purpose, it was requisite, in the first instance, to discover a substance capable of uniting with Glass, but requiring a stronger heat than its transparent enclosure to render it fusible.

About forty years since, a Bohemian manufacturer first attempted to incrust in Glass, small figures of greyish clay. The experiments which he made, were in but few instances successful, in consequence of the clay not being adapted to

combine completely with the Glass. It was, however, from the Bohemian that the idea was caught by some French manufacturers, who, after having expended a considerable sum in the attempt, at length succeeded in incrusting several medallions of Buonaparte, which were sold at an enormous price. From the extreme difficulty of making these medallions, and from their almost invariably breaking while under the operation of cutting, very few were finished; and the manufacture was upon the point of being abandoned, when it was fortunately taken up by a French gentleman, Monsieur de St. Amans, who, with a perseverance not less honourable to himself than in its results advantageous to the arts, prosecuted a series of experiments, by which, in a few years, he very considerably improved the invention. The French have, however, not succeeded in introducing incrustation into articles of any size, such as decanters, jugs, or plates; but have contented themselves with ornamenting smelling-bottles, and small trinkets. Nor had the invention been applied to heraldry, or any other purpose, antecedently to the recent improvements upon the art in this country.

England has long been famed for bringing to perfection, and directing to useful application, the crude inventions of other countries. A patent was, some years since, taken out by the author of this work for ornamental incrustations, called "Crystallo-Ceramie," which excited considerable notice at the time. By this process, ornaments of any description—arms, ciphers, portraits, and landscapes of any variety of colour—are enclosed within the Glass, so as to become chemically imperishable. The substance of which these ornaments are composed, is less fusible than Glass; it is incapable of gene-

rating air, and at the same time is susceptible of contraction or expansion, as, in the course of manufacture, the Glass becomes hot or cold. It may previously be formed into any device or figure, by either moulding or modelling; and may be painted with metallic colours, which are fixed by exposure to a melting heat. These ornaments are introduced within the body of the Glass while the latter is hot, by which means the air is effectually excluded; the incrustation being thus actually incorporated in the Glass. In this way, every description of ornamental Glass-ware has been decorated with embossed, white, or coloured arms, or crests. Specimens of these incrustations have been exhibited not only in decanters and wine-glasses, but in lamps, girandoles, chimney ornaments, plates, and smelling-bottles. Busts and statues, on a small scale, caryatides to support lamps or clocks, and masks, after the antique, have also been introduced with admirable effect.

The composition used in the patent incrustations is of a white silvery appearance, which has a superb effect when inclosed in richly-cut Glass. Miniature landscapes, &c., have been enamelled upon it, without the colours losing any of their brilliancy; and thus, instead of being painted on the surface of the crystal, there are ornaments embodied in it.

A most important advantage to be derived from this elegant invention is the preservation of inscriptions. Casts of medals and coins do not afford security for perpetuating them; but, the inscription, when once incrusted in a solid block of crystal, like the fly in amber, will effectually resist for ages the destructive action of the atmosphere. Had this art been known to the ancients, it would have perpetuated to us many interesting memorials. In laying the foundation of

a public edifice, an incrustation of this kind will be a record *ære perennius*. The late Sir Jeffry Wyatville, in laying the first stone of one of the towers of Windsor Castle, adopted this mode of recording the event; and other architects of eminence have placed these incrusted inscriptions in the foundations of various public and private buildings.

A second patent was subsequently secured by the author, by which medals, arms, crests, &c., are accurately transferred from the dies on which they had been chased, to hollow Glass-ware, especially where numerous repetitions of arms of elaborate workmanship are required. This invention diminishes the expense of engraving, in transferring the pattern by means of cakes of tripoli, from the die to services of Glass-ware, and it has frequently been used with great advantage. It is, indeed, an improvement of Mr. Tassie's mode of accurately transferring small bas-reliefs or intaglio pictures, from any material to solid Glass.

The invention of pressing Glass by machinery has been introduced into England from the United States of America. It has not, however, realized the anticipations of manufacturers; for, by the contact of the metal plunger with the Glass, the latter loses much of the brilliant transparency so admired in cut Glass; hence, it is now chiefly used for common and cheap articles. The process of rewarming or fire polishing, after the pressure, has somewhat remedied this defect. The patent pillar moulded Glass for articles of table use, is more successful, as it preserves its transparent, pellucid brilliancy. The interior is smooth, and the exterior having a second gathering of fused Glass, is expanded by blowing, after it has been impressed by the mould; and by rewarming, technically called fire polishing, the Glass preserves its refractive brilliancy.

Collateral advantages of no small importance have resulted from these inventions; insomuch as they have tended very considerably to enhance the value of British Glass-wares, and to extend the application of Glass to new purposes of domestic utility. The highly ornamental effect which by this and other improvements has been given to the manufacture, has recommended Glass incrustations and other ornamental Glass, in the place of metal ornaments, for door-plates or handles, lamp pedestals, arms, &c., upon decanters, chandeliers, and articles of table Glass.

A third patent has been completed for casting from common bottle-glass metal, water or gas-pipes; but it has not yet practically worked out those results which will, no doubt, be attained by more extended experiments and arrangements.

Sky-lights are moulded in strong flint Glass, of embossed patterns to the segment of a dome, or sphere;* and strong panes for windows, or sky-lights, are ornamented with detached pieces of transparent coloured Glass, massed homogeneously to white Glass, and having together, a Mosaic and ornamental appearance; these being included in the last mentioned patent.

England is pre-eminent for her refractive, colourless, flint Glass for chandeliers and table articles; and the transparent metallic colours are of superior quality. With such materials, when artistic education becomes more extended, the English Glass-makers will, it is hoped, rival their Continental competitors, in colouring, gilding, and elegant forms.

* Upon this principle, the large cut Glass skylight was executed at the Falcon Glass Works, for the ornamental quadrangle of the Reform Club-house, in Pall-Mall; from the design of the architect, Mr. Charles Barry, R.A.

Constituents and Manufacture.

GLASS may be classed into Simple and Compound varieties.

The Simple are, first, Crown Glass, consisting of—

Sand	5 measures
Ground Chalk	2 „
Carbonate of Soda	1 „
Sulphate of Soda	1 „

Secondly, Plate Glass, consisting of—

Lynn Sand washed and burnt	400lbs.
Carbonate of Soda	250 „
Ground Chalk	30 „

Thirdly, Common Bottle Glass, composed of

Sand	100 measures
Soapers' Waste	80 „
Gas Lime	80 „
Common Clay	5 „
Rock Salt	3 „

These Glasses, it will be observed, are composed chiefly of silex and alkali. The Compound Glasses have, in addition to the above ingredients, more or less metallic substances: for instance, white enamel has arsenic, tin, or antimony, entering into its substance, which, as well as lead, form the distinctive quality of the Compound Glasses, materially increasing their

specific gravity, and acting as powerful fluxes. The Compound Glasses are as follow—viz.,

FLINT GLASS.

Highly pellucid and transparent Flint Glass requires—

Carbonate of Potash	1 cwt.
Red Lead or Litharge	2 cwt.
Sand washed and burnt	3 cwt.
Saltpetre	14lbs. to 28lbs.
Oxide of Manganese	4 oz. to 12 oz.

These materials, mixed together, are technically called batch; and when fused, are termed metal.

Soft White Enamel (*Opaque.*)—To 6 cwt. of batch, add 24lbs of arsenic, 6lbs. of antimony.

Hard White Enamel (*Opaque.*)—To 6 cwt. of batch, as above, add 200 lbs. of putty, prepared from tin and lead.

Blue Transparent Glass.—The above 6 cwt. of batch, coloured with 2lbs. of oxide of cobalt.

Azure Blue.—The above 6 cwt. of batch, with about 6lbs. of oxide of copper.

Ruby Red.—The above 6 cwt. of batch, with about 4oz. of oxide of gold.

Amethyst or Purple.—The above 6 cwt. of batch, with about 20lbs. of oxide of manganese.

Common Orange.—To 6 cwt. of batch, add 12lbs. of iron ore, and 4lbs of manganese.

Emerald Green.—To 6 cwt. of batch, add 12lbs. of copper scales, and 12lbs. of iron ore.

Gold Topaz Colour.—The above 6 cwt. of batch with 3lbs. of oxide of uranium.

A beautiful blue may be produced from nickle, but cobalt is generally preferred; the latter, for casing, should be

free from impurities. Glass-makers differ in their recipes for colour, of which there exists a great variety. The above will be sufficient to give a general idea of the principle of colouring.

Suitable cullet, or broken glass, may be mixed with the batch of the above glasses, in quantities at discretion.

The base of all Glasses is sand; and suitable alkali is the chief solvent. In the Compound Glasses, oxide of lead, whether in the form of litharge or red lead, as well as the colouring metals, are active fluxes. These Glasses, therefore, require less alkali, in proportion to the sand, than the Simple. Flint Glass, which ought rather to be termed metallic Glass, needs, for its fusion, less caloric than plate Glass, or any of the Simple Glasses. As the Simple Glasses require intense heat, they are melted in open pots, so that the flame comes at once in contact with the materials. Flint and the Compound Glasses must be melted by the heat going through the pot, which requires to be covered, or hooded; or the fumes and smoke of the coal would carbonize or deoxydize the lead, and precipitate it to the bottom, in its original metallic state. Dried beech or oak wood is used for fuel in some parts of France for Flint Glass, with open pots; and so little carbon is produced by the smoke, as not to affect materially the metal, although the flames play upon its surface. Formerly, flints were calcined and ground, for Glass-making; but for many years past, Isle of Wight, Lynn, or Reigate, sands have been substituted; these sands are not only more free from iron, but less expensive in the preparation, than flints when washed and calcined.

Some manufacturers cleanse sand by hand-washing, and others have machines: to render the Isle of Wight sand fit for

making the Compound Glasses, to cleanse it from chalk and other impurities, by which it loses about one fifth of its original bulk, requires about eight waters; it is afterwards passed through a heated arch, called a calker, and thoroughly dried, or burnt, at the discretion of the operator; and then sifted through a lawn sieve, to separate the larger grains and pieces of coal or coke, and burn off the vegetable matter.

Carbonate of potash, known by the commercial term of pearlash, is imported from British America, and from Russia: it contains, besides carbonate of potash, sulphates and muriates of potash, and other impurities, which will not enter into the composition of Flint Glass. These may be separated, by dissolving the potash in warm water; when cold, the impurities finally sink to the bottom of the vessel, and the lye containing the refined carbonate of potash is drawn off by a syphon, and evaporated to dryness.

This process is, however, rarely practised, as pure carbonate of potash is now obtained from the alkaline residuum of nitric acid—viz., sulphate of potash. Alkali makers at Birmingham and Liverpool supply Flint Glass-makers with refined pearlash made from residuum or caustic potash, so as to save the trouble of refining potash on the Glass-maker's premises.

Litharge is usually produced at Newcastle, in furnacing pig-lead, in order to extract the silver from it. Red lead is made also from furnaced pig-lead to obtain oxygen from the atmosphere; after which it is ground in water, and dried to an impalpable powder. Litharge has but one atom of oxygen; red lead has two, or a double dose of oxygen, and has less power than litharge by about two per cent., which must be allowed for in the mixing.

To the three materials of Flint Glass—viz., sand, red lead, and carbonate of potash, is added a small quantity of saltpetre, which increases the dose of oxygen, and assists to drive off the globules of air in the liquid Glass; there are, also, added to each pot a few ounces of crystallized manganese, the effects of which will be described hereafter. The whole is carefully mixed together, and sifted through a coarse sieve: in this state it is called batch, or frit, and is of a salmon colour. It is by the purity of these materials that the British manufacturer is enabled to maintain ascendancy over the foreigner for pure metal or Flint Glass; and its superior quality is especially due to the excellence of the red lead, which imparts density, refractibility, transparency, and pellucid brilliancy.

If Flint Glass be required of great density for optical purposes, it is only to add a larger dose of red lead, or litharge, beyond what might be termed the atomic mixture of one of alkali, two of lead, and three of sand, (of the specific gravity of 3·200,) and it will produce Glass of higher density, but less permanent, in the ratio of its *increased* specific gravity. Were the proportion of lead twice the atomic quantity, the surface of the Glass would be more or less liable to decompose by exposure to the atmosphere, and need constant wiping to preserve its transparency; it might even require to be repolished for the same object, and that repeatedly. Excess of alkali is equally as injurious as excess of lead, and, indeed, more destructive, through the effects of time and atmospheric influence, as will be more fully explained in a subsequent part of this work. Crystallized black oxide of manganese is best fitted for a Glass-maker's purpose, if well washed from aluminous earth, with which it is ordinarily found combined in mines. The most

permanent Flint Glass is that which by the greatest caloric can be made to contain the largest proportion of silex; but it is not so well calculated for chandeliers, (which should be more highly refractive,) nor for optical purposes, as for ordinary uses.

Flint Glass is remarkably elastic: it may be spun so thin as to bend nearly double without fracture; by the aid of slight heat, it may be curled into ringlets to represent human hair, or it may be blown so thin as nearly to float in the atmosphere; and it has been woven with silk and other substances by Messrs. Williams and Sowerby's Patent Process, so beautifully as to give the brilliant effects of silver and gold, in colours superior to the precious metals themselves.* Hollow Glass balls are so elastic that if dropped from a height of ten or twelve feet upon a solid polished anvil, they will rebound from half to three-fourths of that height, and generally without fracture, until after the second rebound.

Flint Glass, of not less than the usual density of 3·200, well polished by the lapidary, is considered the nearest approach to the diamond.

Glass is admitted to be one of the most useful and beautiful of materials in ornamental and industrial art. Chemistry and astronomy could scarcely exist without it. The delicacy and accuracy of the chronometer require its aid; while the common green bottle Glass can be manufactured cheap enough for casting conduit pipes, for chemical uses, or the supply of the metropolis with pure water. No chemical test is so delicate

* It is not within our province to describe the constituents of arsenic, oxide of tin, or the colouring oxides, which will be found detailed in treatises on chemistry.

as a mass of fused Flint Glass: it will detect the presence of metallic colouring matter, especially iron, although the most carefully conducted analysis may fail in discovering the slightest trace of it. Mr. Josiah Wedgwood found that $\frac{1}{20,000}$ part of gold would give a rose-coloured tint to Flint Glass. With the best possible recipe, and the purest materials, good results depend upon an intense and continuous fusion: too little caloric will fail to refine it, and drive off air-bubbles, and the colouring matter of the manganese; and too long continuance of intense heat will destroy the manganese, cause the Glass to attack the pot, and become striated, gelatinous, and greenish. Extra time, at a lower rate of temperature, will not make up for want of continuous intensity. The most intense heat can scarcely be considered too great; but the moment the metal is fully fused, and refined by continuous rapid fusion, the high temperature of the furnace should be reduced from its maximum heat to a working temperature: this period being considered the crisis. Achromatic plate should be made while the metal is in this quiescent state: it is then most free from striæ; but, should intense heat be subsequently renewed, it tends to reproduce them. There is, therefore, a period of comparative perfection and purity, at which, if Flint Glass be not worked for optic use, the opportunity is for ever lost.

When Flint Glass is kept in fusion beyond *the crisis*, it not only assumes a greenish tint, by acting upon the iron of the Stourbridge clay pot, but takes up a small portion of its alumina; which, by its inferior density, rises to the surface, frequently with detached portions of the pot, causing striæ, and other impurities, which render it entirely unfit for optical purposes.

Although annealed glass will break with the greatest facility by unequal pressure (or vibration of the particles from a centre), yet it is found to withstand uniform or equable internal pressure greater than either of the metals.

The property of welding by contact at about a red heat is peculiar to Glass, whether with or without lead. But for this useful fact in the ornamental department of Flint Glass, as regards the addition of handles, feet, rings, &c., the manufacturer would be left without those manipulatory decorations of his art. So perfect are the weldings, that at the points of union they become as completely one homogeneous mass as if the whole were gathered in one piece; yet, the slightest sulphurous or carbonaceous film intervening between the parts required to be welded, will cause the cohesion utterly to fail.

Another peculiarity, of which the manufacturer avails himself, is the liability of Glass to fracture instantaneously by contact with a cold metal, or by any sudden chill; this causes instant contraction of the part affected, which cracks through the mass by a slight blow, as perfectly as if cut with a diamond. Welding by contact, and separation by contraction, are therefore two principles, without which the manipulations of the Glass-blower would be comparatively inoperative.

Having disposed of a few of the peculiarities and eccentricities of Glass, we proceed to give some account of its manipulatory conditions. One of these depends upon a constant rotary motion being given by the workmen to the Glass gathered upon a hollow blowing-iron, which will, when done with judgment, not only prevent the Glass from falling from its position, but if rapidly rotated, will increase its diameter on the principle of centrifugal force. If a depressed form

be required, the blowing-iron must be held perpendicularly, (with the Glass at the top of it,) so that the shape may be depressed partly by its own gravity, and partly by rapid rotation. Should the Glass vessel be required of an elongated form, the blowing end of the iron must be held uppermost, the Glass downward, and oscillated like a pendulum, or swung rapidly round vertically, thus, again uniting the principle of gravitation to that of centrifugal force.

Before describing the manipulations of moulding Glass or making it by hand, a short account of experiments upon Optic Flint plate may be interesting. For many years subsequent to the time of the celebrated Dollond, English Flint Glass was almost the only heavy Glass used for telescopes, both at home and on the continent. It was generally made from the usual mixture of Flint Glass, with about ten per cent. increase of lead; but still more often of the ordinary mixture (of lead and other materials), and of the specific gravity of about 3·250 to 3·350. The process is as follows:—A ladle, in the form of a sugar-loaf, about five inches in diameter and seven inches deep, is dipped carefully into the metal, which has been previously skimmed; when filled, it is taken out of the pot, and suffered to get partially cool; to the large end of the sugar-loaf shaped piece of Glass thus produced, a Glass-blowing iron with a hollow disk is welded, and placed to the opening, or mouth of the pot for re-heating; when sufficiently soft, it is blown into a muff, as hereafter described, and illustrated, under the head of the Cylindrical Lamp Glass: the end furthest from the blowing-iron is cut off, the cylinder is flattened into pieces or plates of fourteen inches long, ten inches wide, and of about half an inch thick, and an-

nealed; in which state, the plates are sold to the optician, for cutting and grinding into disks

Since the time of Guinand, of Brenette, in Switzerland, and of Frauenhofer, and others who have done good service to science by their meritorious labours and improvements, the opticians of England have imported many large sized achromatic Glasses from the Continent; although the British manufacturer, (who only occasionally makes for home use,) still supplies eminent foreign workers with Glass for optical purposes, some of which, no doubt, finds its way back into England, as foreign, at a very advanced price. Guinand's plan has already been published: the secret of his success is considered not to have been in the novelty of the materials or proportions, but in agitating the liquid Glass while at the highest point of fusion, then cooling down the entire contents of the pot in a mass, and, when annealed and cool, by cleavage separating unstriated portions, afterwards softening into clay moulds. Dr. Faraday is of opinion that the usual materials of British Flint Glass are excellent; and that the necessary improvement is chiefly mechanical, and not chemical. As a proof, the very heavy Glass he has produced owes its freedom from striæ to his plan of constant agitation, as detailed in a paper communicated to the Royal Society, in the year 1829. M. Bontemps, a scientific French Glass-maker, has succeeded in making good Flint optical Glass also on the principle of mechanical agitation; and was rewarded for his process by the French Society of Arts, in 1840. In the year 1845, he published the result of his experiments.

M. Bontemps operated in conjunction with one of the sons of Guinand as follows. A long hollow cylinder or sheath of fire-clay closed at one end, with a bore sufficiently large to admit of a strong blowing-iron, was brought to a red heat, and introduced

into a pot of melted Glass. This agitating iron had a long handle with a flat ring, or hand-guard, which rested while in use upon the shoulders of the pot: it was then introduced into the fire-clay cylinder, or sheath, and when the metal was at its utmost intensity of fusion, the mixing began, and continued for many hours, until the operator presumed the striæ were dissipated; then, by gradually reducing the heat of the furnace, the Glass became too stiff for agitation, and the pot, and its contents, were annealed in the furnace. Crown Glass will not allow of so many hours' intense fusion and agitation as Flint Glass, owing to its liability to devitrify. M. Bontemps does not assert that he always succeeded in the stirring system, for Flint Glass. He sometimes found hard masses of small cords, as it were, felted together: these he thought were caused by the chemical action of the Glass upon the fire-clay cylinder and pot; but they spread in the operation of cooling. His plan of cleaving pieces from the blocks of Glass, and softening the disks in moulds, was similar to that of M. Frauenhofer. He suggested an iron agitator cased in platinum as a practical improvement, which the author of this work thinks is chemically objectionable. He also recommended that an entire pot of flint metal, fused upon the agitation system, should be emptied upon an iron table, and cast the same as Plate Glass. Mr. Dollond has used this kind of French Glass with partial success, although it has not generally been sufficiently annealed. M. Bontemps's proportions are as follow:

For Flint Glass—

Sand	43·5
Red Lead	43·5
Carbonate of Potash	10
Nitrate of Potash	3
	100

For Crown Glass—

Sand	60
Carbonate of Soda	25
Carbonate of Lime	14
Arsenic	1
	100

On examining the records of these practical modes of obtaining the best achromatic Flint Glass, it will be found that our philosophic countryman, Dr. Faraday, (the plan of Guinand being then a secret,) suggested the same idea of stirring, which was carried out successfully in the heavy Glass he manufactured. This was composed of—

104 Protoxide of Lead.
24 Silicate of Lead.
25 Dry Boracic Acid.

His Glass required but a red heat for fusion, thereby offering facilities for minute agitating operations. Although it is not calculated for permanence or general use, its manufacture developed the fact, that the destruction of striæ is more dependent upon mechanical than chemical appliances; and that Dr. Faraday's conclusions and those of MM. Bontemps and Guinand, jun., were identical in principle. The question may be asked, Why should there be difficulty in obtaining good achromatic flint Glass? There would be none, (is the reply,) if a manufacturer could anticipate a fair remunerative price and demand, after having succeeded in obtaining the quality. Probably, he could only sell 600 cwt. per annum, even were he to supply all the opticians in Great Britain at ten times the price of ordinary Flint Glass, which would scarcely be remunerative, whether he manufactured in one of the pots of a ten-pot furnace, containing each fifteen or eighteen cwt.; or upon a smaller scale, in

a furnace of one or two pots not exceeding fifty pounds each, kept working for that sole purpose. In the ordinary course of Flint Glass manufacture, working a large pot of Glass for optical purposes not only retards general operations, but usually spoils the greatest part of its contents, whilst the quantity of optic plate produced is comparatively small, and uncertain in its results; and if unfit for the optician, it becomes valueless to the manufacturer for other purposes. As an affair of science and merit, especially were a Government premium offered for an uniformly certain process, which has not yet been accomplished at home or abroad, it is anticipated that English manufacturers would rival foreigners in this field of honourable competition. The author has constructed a small furnace, to try the principle of agitating fused Flint Glass by a rotating pot, with one or more interior divisions: and this means of subjecting the Glass to an uniform intensity of caloric and agitation in a covered pot destroys the striæ or cords by mechanical means, without exposing the contents to the cooling effects of the atmospheric air.

Flint Glass works require a very considerable area of ground —viz., about half an acre or more—to conduct the various operations; and separate apartments are requisite for washing sand, refining alkali, and picking and washing broken glass, technically called cullet; besides mixing-rooms, &c., there are, likewise, requisite one or two furnaces, usually with ten melting pots in each; a horse or steam mill, for grinding old crucibles or pots; from two to four arches, with their fire-places, for annealing Glass; and large rooms, or lofts, in which to mix clay for making pots and crucibles; besides store-rooms and a packing warehouse. The whole should be so planned, that the crude materials in the course of pre-

paration and mixing are always *moving* upwards to the fusing furnace; and when manufactured, they are placed in the lears, and drawn downward by machinery towards the warehouse, packing-rooms, or cutting-shop; which arrangements prevent breakage, and unnecessary moving of tons of materials. Besides the above, are a steam-engine, shafts, lathes, and tools in the cutting-shop, stoppering lathes, &c.; so that the whole of the processes may be conducted on the same premises. A furnace for burning the sand, another for getting up the pots to the requisite white heat, preparatory to placing them in the fusing furnace, also form part of the establishment.

The erections, with fixtures and implements, for two ten-pot furnaces, capable of melting in each, per week, about 12,000 or 15,000 lbs. weight, (from which can be manufactured weekly into wares about 6000 lbs.,) will cost from 12,000*l.* to 15,000*l.*, besides the expense of the ground. Thus, extensive Flint Glass works in good situations may be estimated to cost about 20,000*l.*: they will be capable of making weekly about 12,000lbs. weight of manufactured goods, half of which will have to be cut or stoppered; and the total annual returns at wholesale prices may be estimated at about 25,000*l.* With the exception of the pot-rooms and cutting-shops, all the processes of a Glass manufactory are conducted on the ground-floor, as it would incur great loss of labour to move heavy masses of material into upper rooms.

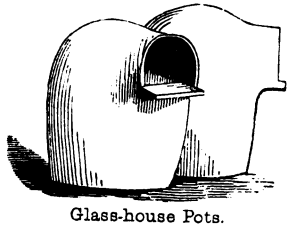
The management of Glass-houses in France and in England is uniform in the respective countries; but differs from each other very materially.

The French, work and fill continuously—that is, the whole of the workmen gather simultaneously out of two or three pots: these, when emptied, are immediately refilled with mate-

rials, twice or oftener in the week; while these are fusing, the workmen gather out of other pots, so that all the pots are consecutively worked out twice or thrice weekly. By this mode, a greater quantity of Glass manufactures can be produced than by the English management; but the pots must be comparatively small, the metal will not generally be so well refined, and the fusion must also be conducted in the shortest possible time. Large quantity and low price being the chief desiderata, the men work the entire week at weekly wages, (except during twelve hours on the Sunday), which is the most economical method.

English management has been uniformly the same during the last half century. As the Excise found its system, so, by its stringent and vexatious regulations, it continued to the termination of its destructive reign; and, although its injurious shackles are now removed, long habit, the difficulty of getting workmen to labour during the entire week, and the alteration of English piece-work to French time-work, (notwithstanding an increased weekly remuneration would be the result, (would render it difficult to effect a change. Circumstances and competition may, however, prove the disadvantage of our present management, at no distant period, and compel home manufacturers to adopt a more economical arrangement.

In a Glass-house in England, the pots are filled but once a week, usually on Friday or Saturday morning. Wood vessels, like hand-barrows, are used for bringing to the furnace the mixed materials, which are thrown into pots, holding about 18 cwt. each, in quantities of about 4 cwt. at



Glass-house Pots.

a time, with iron shovels, allowing sufficient time between each filling, for melting down the various charges, until the pot is entirely filled with fused Glass. By this method, every pot in the furnace is fully charged with liquid metal, in about twelve to fifteen hours; air-bubbles and striæ then abound, and they are not expelled until thirty to forty hours more have elapsed, during which period—viz., from fifty to sixty hours, the gas and air-bubbles are driven off, and the mass becomes homogeneous. English melting-pots, being usually much larger than the French, require a longer period for fusion, thus increasing the difficulty, if a second filling be required during the week; but the Glass is not usually so pure as the first, through less time being allowed for the second fusion. When all the pots are filled, and the mouths are securely stoppered and clayed up, the founding commences, during which thirty to forty hours (as before alluded to) the furnace is urged to its utmost intensity; no pyrometer is used, as the heat varies according to the condition of the furnace, aspect, and intensity of the wind, quality of the fuel, and attention and tact of the *tiseur*, attendant, or stoker. Nevertheless, there are certain signs by which a practised eye can detect the fitness or unfitness of the metal for working: these are—the whiteness of the flame exuding from the furnace, on each side of the pot; also by occasionally withdrawing, with an iron rod, a little of the melted Glass from the top of the metal, through a small sight-hole in the stopper, and at fixed times taking proofs of the metal. Saturday and Sunday are the days when the furnace requires the greatest heat, so that the working may be commenced early on Monday morning.

The shorter the time of fusion and refining, the better: for

this purpose, the heat can scarcely be too great: driven snow is not whiter than the burning coal in the centre of the furnace, when it has reached its maximum of intensity.

If the Glass do not get fine by the usual time allotted, and it should become coddled or gelatinous, it never will recover, however urged by subsequent fusion. Such Glass must be ladled into water, and considered only as cullet for re-fusion, with a proportion of new materials.

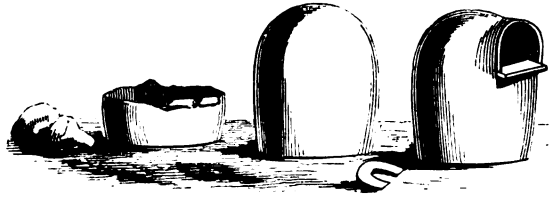
The man who acts as *tiseur* has a substitute allowed him every other Sunday. One man only is necessary to attend the furnace while founding; but a boy, in addition, is desirable, in case of accident by broken pots, that he may be sent to procure assistance, should it be necessary; or that he may, in such cases, suddenly ladle the remaining contents of a broken pot of Glass into water, to prevent its running to waste through the bars, and checking the heat of the furnace.

Formerly, scum, or *sandiva*, was allowed to run off, or was taken off the surface of the pots when opened for working, on Monday mornings; but the modern relative proportions and purity of the chemical materials are so good, as seldom to render this skimming necessary.

The blowing process commences on Monday early, and ceases on Friday, in the morning, or towards noon, so that the blowers have part of Friday and the whole of Saturday, for recreation: still, it is not found that the average health or longevity of English workmen is superior to the French, who work throughout the week. Both French and English have two sets of workmen, day and night, relieving each other usually every six hours; but in some parts of the Continent,

the change is only every twelve hours, with suitable time for refreshment, &c.

The English blower works about forty-eight or fifty-four hours; and the French, seventy-two hours per week.



GLASS-HOUSE POTS.

The most important department of Glass-making is the manufacture of the melting-pots. For this purpose, the best Stourbridge clay, in the lump, should be selected, and only that part ground which is free from impurity: this peculiar fire-clay is usually found in iron districts; the best is from Stourbridge, in Worcestershire; it may be termed a silicate of alumine. Too much of the latter would render it too fusible; and if in excess of silica, it would fail to cement the mass efficiently, so as to bear the weight of the fluid Glass, viz., about eighteen hundred weight. Rather too much alumine is usually found in this sort of clay, and pots stand better by having about one-fifth in quantity of old pots ground, and used with four-fifths of new clay, which mixture retains sufficient tenacity. The ground potsherd not only assists to dry the pots more regularly, but it renders the whole body more porous, and less likely to split by sudden heat. Very few manufacturers use pots made from new material only.

The chamber where the clay is kneaded, and the pots are

built, should be well selected: not too distant from the furnace pot-arch, of uniform temperature, neither below fifty-five nor above eighty—above eighty would dry the pots too fast, and below fifty-five is not desirable, although a temperature as low as thirty-two would not absolutely injure them. A middle or ground floor is preferable to an upper floor, which in summer would be too much exposed to the heat of the sun, and in winter too cold. The ceiling should be well secured against particles of plaister dropping into the clay, and the floor should be well ploughed and tongued, to prevent a substratum of cold air, which in any case is difficult to avoid. At only four feet from the floor, the upper and lower temperature will often differ as much as ten degrees, to the great danger of breakage in drying.

Three months may be adequate for drying a pot, but four or six months are preferable; the large covered pots, similar to those in the engraving, will contain about eighteen hundred weight of melted glass: they measure three feet external diameter, and three feet high, to the filling part, and weigh about ten hundred weight. This description of pot is used for white Flint Glass; for coloured Glass, three small pots, two side by side and one above, are used in melting; and the three fill up the same space in the furnace as that occupied by one large pot of the above dimensions.

Pots for coloured glass.

Upon the durability of the melting pots, (all other arrangements and management being good,) the profit and success of the manufacturer chiefly depend. Large melting-pots, with the cost of coals and attendance to heat them for the furnace,

are estimated to cost 10*l.* each. The least number generally required, (with good success,) for a ten-pot furnace, is from ten to fifteen pots per annum; but some manufacturers have set as many as fifty new pots in one year. Not merely is the expense of the pots to be considered, but the disappointment in not being able to execute orders that may be pressing, and the loss of metal running out of the broken or cracked pots through the furnace; whilst the fixed expenses for fuel and establishment are the same for the production of a small as for a large quantity of manufactures. During the Excise reign, no pot could be moved from the spot where it was dried, to be placed in the annealing arch, without a notice in writing to the supervisor; a second notice was required for gauging; a third for setting it in the furnace, again for filling the pot, and another for ladling it out; whilst the maker was forced to comply strictly with the act of parliament, by giving the officer six hours' notice for each of these intricate and vexatious requirements.

Foreign melting pots are usually made in wooden moulds, lined with cloth: if small, this plan answers where a great number are required; but British manufacturers almost invariably build their pots without moulds. The old and new clay being mixed together, and allowed to be saturated fully with water, the process of kneading by men's feet is repeated three times over, until the mass has a pasty consistence. It is then rolled into small pieces, about the size of a sausage; these wet clay-rolls are placed together (upon a lead slab) to the thickness of full four inches, to form the bottom, which is beaten with a wooden mallet, and pressed with the hand; the sides are raised by pressing the clay sau-

sages from the inside of the curve upon preceding rolls, so as effectually to exclude the air, leaving the substance of the sides from two and a-half to three inches thick; the dome is continued in the same manner, circle upon circle, roll pressed upon roll, until the roof is completed, each circle diminishing towards the centre. It is then left, and the air within becoming somewhat rarefied, supports the dome until the pot is sufficiently hard to allow of cutting open and finishing the mouth. Kneading by the naked feet answers better than kneading by a pug-mill or machinery; the latter was tried at the Falcon Glass Works on a large scale, scarcely a single pot out of fifty or sixty was capable of holding Glass. The weight of the human body, the elasticity of treading, and the warmth of the feet, probably expel the air from the clay, better than machinery.

When the pots are dry, they may be removed to a hot room of one hundred to one hundred and fifty temperature. Before setting in the Glass furnace, great care is necessary to anneal a pot in the arch; and a week or more should be allowed gradually to bring it to a white heat, ready for pot setting. This work is always performed towards the end of the week, and is a hot and fatiguing operation; all hands must be present, and absentees, except from illness, are severely fined. The men are provided with suitable dresses to shield them from the open blaze of the furnace. The old pot, being no longer useful, by age or accident, is then exposed, by pulling down the temporary brick-work; a large iron bar, steeled and sharpened at the point, is placed across another bar, to operate under the pot as a fulcrum; several men rest their entire weight upon the end of this long lever, and,

after one or many efforts, and perhaps many more simultaneous blows of the bar, used as a sort of battering-ram—the old pot, either wholly or by pieces, is detached from the siege of the furnace.

About six or eight men take afterwards each a bar about five feet long, like a javelin steeled and sharpened at one end; they rush forward in face of the fiery furnace, guarding their faces with their protected arms, and aim a blow at such of the irregular rocky incrustations of clay as adhere to the siege. This operation is repeated until the pieces of partially vitrified clay are wholly removed from the position on which the old pot stood, which should be repaired with clay and sand. The new pot, at a white heat, is then removed from the annealing pot-arch, and carried upon the end of a two-wheeled iron carriage with a long handle, by four or more workmen, who carefully set it or tilt it backwards into its proper position in the furnace.

In the interim between removing the old and setting the new pot, an iron screen is placed before the opening of the furnace, which, having lost much of its heat, is urged gradually to its original high temperature. Seldom more than two pots are set in one week; to do more would endanger the other pots in the furnace, by their getting too cold, through the furnace remaining so long open. The fatigue and exhaustion of the men, who are often detained four hours in this operation, is also very great, and is attended occasionally by severe falls, burns, or bruises, by liability to catch cold, great excitement, energetic exertion, and exposure to the flame of the open furnace. Good pots will average three months each in the furnace, and some are known to last above twelve months; in this case, they

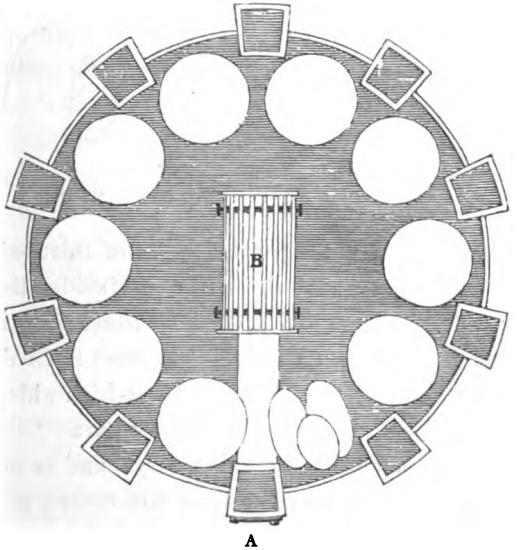
wear dangerously thin at the back, where, should they suddenly burst, nearly the whole contents would be lost in the furnace. Glass-makers patch up pots in the crown or in front, and occasionally at the bottom. A pot split dangerously in the front is preserved from leakage for several weeks by exposing the cracked part to the atmospheric air, (first taking away the temporary brickwork in front,) which chills and hardens the metal as it exudes, until it is stopped by its own leakage. Should the temperature of the atmosphere be insufficient to check the leakage, cold water must be thrown upon the fissure; or a piece of black Glass or common bottle metal softened by heat, and plastered upon the opening. A crack in the bottom may sometimes be prevented from leakage by lifting the pot and contents by leverage upon fire-bricks, and exposing the bottom to air or water, as before described; but the latter seldom answers, although a broken-fronted pot may last many weeks, and fuse metal moderately well.

Elevation of the furnaces, and interior view of the Glass-house and working operations.

FURNACES.

A flint Glass furnace, in principle, is intermediate between an air furnace and an oven: too much draught would drive the caloric up the chimney or shaft, and too little would fail to yield sufficient oxygen to support the requisite heat. The draught must never be too strong to prevent a plus, or pressure of short and sharp flame outwards from the bye-holes of the furnace on each side of the pot mouths. Large caves,

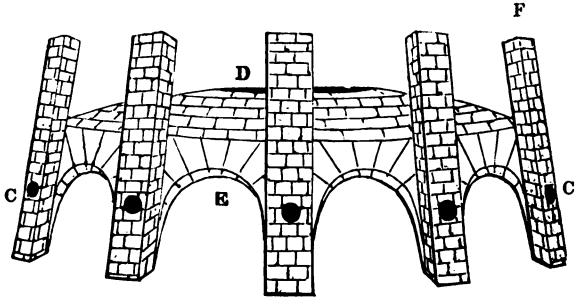
extending through the subterranean area of the Glass-house, connected with the open air at each end, under the bars of the furnace, receive the fallen cinders, and supply the oxygen necessary for the combustion of the fuel. At right angles with the large cave, are smaller caves, communicating so as to catch the wind from as many aspects as possible.



Ground plan of the siege flues and fire-place of the furnace, with nine large pots and three small, in their respective positions.

The coals are shovelled through the square hole (A), on to the grate, in the centre of the furnace (B); two strong iron sleepers support the bars, which are prevented from melting, by being previously covered with a layer of clinkers, pot-sherds, or broken Welsh lumps; but as the furnace, in process

of time, gets to its maximum heat, it usually forms sufficient clinkers from the coals; the potsherds are then no longer needed.



Interior view of the Stourbridge brick dome.

Dimensions of a furnace for ten pots, of thirty-six inches diameter—viz., twelve feet seven inches inside diameter of the siege; nineteen feet outside diameter; including the flues; four feet six in height to the inside centre of the dome (D), each of the arches (E), being three feet one inch wide, by three feet three and a half inches to the highest part.

A Flint Glass furnace is reverberatory: and as no heat or flame is usually allowed to issue from the centre, it therefore seeks escapement through the linnet holes (C), below the foot of the dome, and passes up the flues (F), viz., one between each of the ten pots placed around the siege, discharging the smoke, &c., into the outer brick dome, as shown in page 56, and from thence through the funnel and chimney-shaft. The duration of a furnace is scarcely ever less than three years, and often exceeds ten years, according to the quality of the Stourbridge clay bricks: some of these weigh nearly half a ton; they are

usually made from two parts of ground potsherd, (the glass being carefully chipped off,) and one part of new clay, kneaded by the feet, &c. Occasionally, the siege, or bottom of the furnace, is repaired, and a new crown (E), or the greater part of the crown, renewed, without extinguishing the furnace.

In case of accident, which is not unfrequent, as the falling in of part of the arch, or crown of the furnace, the *tiseur* must throw upon the bars as much fuel as possible from the teaze-hole, and then, through the breach in the crown, fill the entire furnace with a solid mass of coals and cinders; the upper part of which forms a centre upon which to build a new crown, or arch. The draught is thus almost stopped, and but little consumption of coal takes place, while the workmen are proceeding with the new arch, under the inconvenience of the smoke and heat of the furnace. The pots remain partly or wholly full of metal. When this is completed, the furnace is gradually urged to a maximum of heat, and the debris is taken out by degrees into the cave beneath, by removing a bar or two. In the course of twelve hours, by means of prepared arch-bricks, and Stourbridge clay as mortar or cement, the repair of a fearful accident in the midst of the blowing operations has been completed by the workmen; and that without materially, if at all, diminishing the weight of the week's work of manufactured Glass.

Round furnaces are most economical, and almost exclusively used for Flint Glass works. Economy of fuel greatly depends upon the size and proportions of the furnace: too large dimensions leave too great an area unoccupied by the pots or the fuel; and too small a furnace exposes the backs of the pots, (which are placed round the exterior diameter of the

furnace,) to hang over the fire-place in the centre; this in time enlarges by burning away, and causes them to crack at the bottom or back, by cold draughts through the fire-bars, if holes are too suddenly opened beneath by the *tiseur*, for the admission of air to urge the heat of the furnace after pot-setting. Occasionally, too, when the centre part of the siege has been partly destroyed by the flame, a pot full of liquid Glass has been known to fall back into the fire-place, or grate; and, as the intense heat prevents any means of raising it again to its erect position, with iron boat-hooks, which become straightened by the melting heat of the furnace, the back of the pot must of necessity be tapped with an iron bar through the grating below, and the whole contents allowed to run into the arch beneath the furnace. The author has been present on such an occasion, and finds it difficult to describe the awful beauty of the prismatic colours of the liquid fire, as it showered into the cave.

Ten pots of thirty-six inches diameter are the medium number for a well proportioned furnace, and are found the most economical for fuel.

The crown of the furnace should be as low as can be built, to support itself, and to admit the pots, that the fuel may not be wasted by heating a useless interior area.

The consumption of fuel by a well constructed ten-pot furnace will be from eighteen to twenty-four tons of coals weekly, in the furnace only. A furnace of twelve pots, exposing a much larger unoccupied area, in comparison with a ten-pot furnace, will consume nearly double the quantity of fuel; whereas, twelve pots of melted metal will hold only in the proportion of one-fifth increase. Furnaces of less dimensions

than eight pots are objectionable, through the great loss of pots in consequence of the comparatively small size of the siege, as before explained.

The manipulatory operations of Glass-making are totally dissimilar to casting metals of any kind. Scarcely any advance in this department of the manufacture has been made for above two hundred years; and the tools then used for blowing, and shaping the various articles have been since but little improved. The reason is obvious: the formation of the infinite variety of wares produced in Flint Glass-houses, relies more upon skill, adroitness, and tact, which may be termed the *main-d'œuvre* of the art, than upon the ingenuity of the tools:—in truth, the perfection of the product of the furnace, as regards its workmanship, depends chiefly upon the tact and intuition of the Glass-blower, avoiding as much as possible the use of tools. The more these shape the article, the more imperfections are likely to be produced by the scratching and rubbing of the iron; although this is partially avoided by the use of modern wooden charred tools. Iron tools should only be employed in the earlier process to produce the crude form, and the wooden tool used but sparingly; whilst the finishing and intermediate shaping depends chiefly upon the application of centrifugal force, by rapid hand rotation; upon the expansion given to air to widen the forms while reheating at the aperture of the furnace, technically termed "flashing;" and upon a skilful final throw.

ANNEALING.

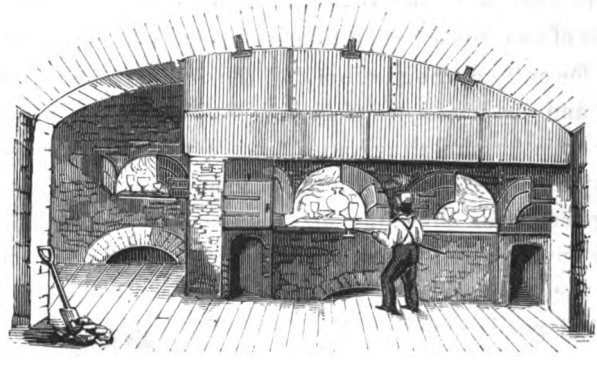
Heat more or less expands all metals, which again contract in the cooling; and, with the exception of cast-iron under peculiar circumstances, no danger of fracture is caused even by rapid cooling. Flint Glass, on the contrary, owing to its peculiar crystalline structure, especially when of unequal substance, is subject to fracture by sudden exposure to friction or the ordinary temperature of the atmosphere, and particularly so in frosty weather; it cannot, therefore, be too carefully cooled to allow a gradual contraction, and the crystalline particles to settle equably into their ultimate position. The process of annealing becomes to the workmen and manufacturer of the greatest importance, and needs the most careful and scientific arrangements to prevent cold currents of air from coming in contact with the glass while gradually parting with its caloric. Metals being more or less crystallizable, under some circumstances, are subject to fracture by a sudden blow or friction; and Glass exceeds every other crystallizable sonorous body in this peculiarity. No contrivance can be practically too costly, which will effectually anneal so brittle a material as Glass; and it is false economy to save fuel in the process, when a greater body of caloric, at a greater cost of fuel, would give additional security. Fracture is supposed to arise from derangement of the atoms by unequal contraction or tension: thus, the interior of a hollow vessel taking more time to cool than the exterior, tends, by unequal contraction, to derangement and fracture, by crushing the particles; and this can only be remedied by the external heat of the annealing fire allowing the two surfaces to cool simultaneously. The more

massive, therefore, the Glass is, the more difficult it is for the caloric safely to be given off. Therefore, when a piece of Glass has to be reheated, as in the case of a lamp Glass, it should be of a medium thickness; not too thick to prevent the heat from quickly travelling through its substance; nor too thin, to be subject to break by the friction or tension of cleaning. The same remarks will apply to tubes intended for steam gauges: which should be subjected to special care and time in the process of annealing. Hot water, or heated sand, would be equally serviceable as an annealing medium: heated air is most convenient for general purposes, although the two former are occasionally used.

A piece of unannealed barometer-tube, forty inches long, measured when just drawn, will become about one-fourth of an inch shorter if annealed; whereas, if quickly cooled without annealing, it will only contract about one-eighth of an inch, Should Flint Glass of unequal substance be insufficiently annealed, such as is not broken in cutting may be placed in a sand and water bath nearly cold, there very gradually heated to the boiling point, and kept several hours in a state of ebullition; the heat may then be reduced, and the whole suffered to get gradually cool. This process has scarcely ever been found to fail.

However carefully tube gauges for steam-boilers may be annealed, even after long use, great danger is caused by cleansing the inside: it is well known that a few grains of sand shaken inside a piece (or proof) of unannealed Glass will cause a violent fracture; and the same effect to a less degree may be produced in an annealed tube. Probably the outside, being more exposed to the lear fire, gets better annealed,

and becomes more contracted; consequently, an unequal tension disturbs the inner crystalline particles, when deranged by the interior friction of cleaning. Striated tubes should not be used for steam gauges, as the striated parts will not contract or expand uniformly with the parts that are free from striæ.

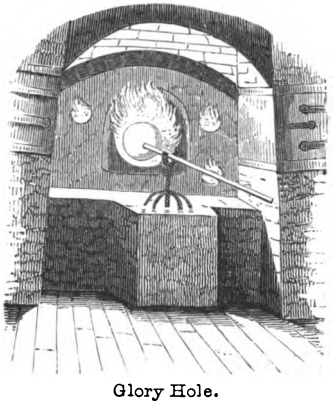


Front view of the annealing arches, showing three sets of pans heating each with a separate fire, with the same cylindrical brick arches and cast-iron doors

A lear is the term given to an arch, or oven, open at both ends. Each lear has a small furnace at the receiving end or side nearest the large Glass furnace; the hot end may be termed the receiving end, and the cooler the discharging end; the latter terminates with a chimney, and the hot end is kept at a temperature just short of a melting heat. The caloric is sustained by oven-burnt coke, which imparts, decidedly, the most regular heat for annealing, and is the freest from smoke, the carbon of coal smoke being generally injurious to the colour of the Glass. There are from two to four of these semi-cylindrical arches, built side by side; on the floors of these are placed iron pans to receive the manufac-

tured goods, which travel upon a miniature railroad gradually downward from the heated to the cooler end, a distance of about sixty feet: one-fourth of the length of this distance is arched, and leads into an air-tight receiving or sorting room, from which the goods are ultimately removed. If there be two or more lears, or arches, in one house, there should be various degrees of heat in each; the highest being intended for strong goods for cutting, the medium for the ordinary run of table Glass, and the lowest for vials or light lamp glasses.

The time for annealing varies from six to sixty hours, the weighty articles requiring the most heat and time. The best arrangements for annealing may be foiled, should the Glass-blower unnecessarily lose time after finishing the work; as the hotter the goods enter the arch, the better; on this account, the large goods receive a final reheating at the mouth of a pot heated by beech-wood, and called the Glory Hole. Successful annealing depends much upon the proper direction of the wind: the best aspect for this purpose is when it passes over the fuel of the lear toward the lear chimney, so that the hot air is always radiating in the downward current upon the goods. Great losses accrue from breakage, when an upward or contrary current of wind drives back the heated air from the cool or chimney end, toward the fuel at the upper end. While annealing, the lower, or discharging end of the lear,



Glory Hole.

was formerly always under the lock and key of the Excise-man; often to the great injury, and always to the great inconvenience, of the manufacturer.

Goods for cutting, requiring extra care and time in the lear, are protected from cold draft under semi-cylindrical arched iron covers, technically called "omnibuses;" or, when very massive, the goods are immersed in hot sand. Kilns were formerly used for annealing almost universally to render the Glass fit for the severe friction of deep cutting. There is a great distinction between a kiln and a lear. The kiln, when in use, is closed at the further end; whereas the lear is open at both ends. The kiln, when filled with goods carefully placed in pans, is closed, with the burning fuel also; the openings, or interstices, in the event of the door not shutting accurately, are sealed up with clay; and the time required to cool is usually about a week. This period seems very long in comparison with the short time allowed for the lears; but, as the Glass in the kiln is immured with the burning coke, which consequently parts with its caloric very slowly, it will require nearly that period to allow the Glass to become sufficiently cool to be handled, or to expose it to the ordinary temperature of the atmosphere. The lear admits the goods to be continually drawn more quickly, although by slow degrees, away from the burning coke; and the glass, therefore, more readily cools. Kilns are objectionable through causing so much delay; and dispatch being the order of the day, they have been superseded by the use of iron covers, or sand, in lears, as already stated: likewise by lengthening the lear fire-places, and not filling the pans with Glass too fast, as well as by great attention to the regularity and intensity of heat; it being the instruction

to the lear-man, or fireman, rather to run the risk of melting goods by excess of heat than subject them to fly by insufficient heat.

Cast-iron doors, making the openings toward the Glass-house larger or less at pleasure, are a great improvement; these openings should always be as small as possible, except when the larger goods are admitted. They are closed effectively but once a week. When the Excise upon Glass existed, the lear was secured by fastenings and locks,—supplied by the Government officer at the expense of the trader, and safely secured every Friday or Saturday, and not re-opened till the Monday following. During the whole of the week, the officer had the surveillance of the lear, but especially of the sorting-room (at the delivery end of the lear), which was only entered at the stipulated Act of Parliament periods. If a link forming part of the endless chain running under the lear, connected with the machinery, drawing down the pans, accidentally broke in the night, and the officer should happen to be absent, (which was rather the rule than the exception,) either the whole works must be stopped, or some mode adopted for the learman to repair the mischief not strictly in keeping with the Act; so that while the principal was quietly reposing in his bed in imaginary security, his servant, unknown to him, had almost necessarily incurred ruinous Excise penalties. The Excise officer gauged the liquid Glass in the pots, which he had the option of charging by weight, at a specific gravity of 32·00; and should the manufactured annealed goods ultimately not amount to two-fifths of that estimate, he had to pay the difference. The lear charge was always considered to be the chief security, as indeed it really was; still, with the utmost

Excise vigilance, the trader occasionally defrauded; but owing to the great heat of the arch, and the usual Excise securities, the revenue was, on the whole, well secured at the lears. Had the lears or kiln been the only departments of the works under Excise survey, the manufacturer would not have been so much inconvenienced. The surveillance of the pots was his chief annoyance, since it required endless trouble, and subjected the manufacturer to danger of Exchequer prosecutions. To throw into the pots ever so small a piece of metal, during the working, incurred a penalty of fifty pounds for every offence. Neither plate Glass nor bottle Glass manufacturers were subject to the surveillance of the pots: this made it exclusively injurious to the flint Glass maker, and was almost a prohibition of alteration of tint, or experiments, and consequent improvements.

It is matter of astonishment how Flint Glass works existed at all under such a concentration of commercial and manufacturing hinderances as were imposed by the Excise regulations; happily, the incubus exists only in reminiscence.

To return to a few of the curiosities of Annealing. Coke, as has been stated, is the best fuel for this process: it is the most steady and uniform in its calorific powers. Oven-burnt coke is stronger and much more lasting than gas coke; another advantage is, that it is the most free from carbonaceous fumes, or smoke. Fluid Glass need not, therefore, be tinted in excess, only a minimum quantity of manganese being in such case necessary. If coal be used, the smoke, acting by its carbon upon the Glass, will render colourless the

reddish tint arising from a maximum or excess of manganese; or, if the glass be previously colourless, it will cause a greenish tint to appear, which the manganese had dissipated: therefore, carbon would seem to be a neutralizer of oxygen, and practically a dissipater of the colour, caused by manganese. But should the Glass thus lowered in tint be re-melted, or only softened by the drop pincher, in moulding it into prisms or ornamental drops, the reddish tint will again appear; as if (which is probably the case,) the carbon received in the annealing had again been dissipated, and replaced by oxygen in the process of pinching. However massive may be the piece of flint Glass, which is the medium of these changes, the purple tint of the manganese, the greenish hue from iron, (the impurities of the lead or other ingredients,) not only adhere to the surface of the Glass, skin-deep, but extend to every particle of the central and general mass. That these alternate changes are the result of two antagonist chemical agents appears confirmed by the fact of Glassmakers resorting to carbon for the neutralization of the manganese reddish tint, when in excess in the fluid Glass; this is done by agitating it in the pot with a wooden pole or burning staff, the carbon from which is found to have the effect of dissipating the manganese colour. An excess of nitrate of potash or soda has somewhat the same colouring effect as manganese, arising probably from its abundance of oxygen.*

* The Glassmaker is well aware, when mixing materials for filling the pots a second time in the same week, consisting chiefly of cullet, or broken Glass, and saltpetre or other alkali, with but little if any new or virgin

Devitrification, which is caused by excessively slow cooling, occurs more frequently in the simple than in the compound Glasses, and destroys the crystalline properties of Glass. Its appearance in crown or common bottle Glass is that of a multiplicity of small petrified star-fish, or rays diverging from different centres, in little groups resembling an opaque or partially opaque whitish clay, or Reaumur's porcelain occasionally, surrounded by or encrusted within the transparent Glass; when it exists in great masses, prior to its becoming quite opaque, it has a beautifully variegated effect, like a precious stone. It is the bane of the Glassmaker, and occurs when, from a state of fusion, the Glass is allowed to cool too slowly. Sir James Hall, in investigating the cause of devitrification, gave a piece of green Glass this opaque character by very slow cooling; but the Glass, in re-fusion, required a very intense heat to cause it to resume its transparency. Whatever may be the cause, Glassmakers well know the remedy; and when, from certain tendencies, this annoyance is likely to occur, if there be thrown into the fluid Glass a quantity of common clay or silicate of alumina, it will soon become fused in the mass, and prevent the evil. Partial devitrifi-

materials, of sand, alkali, or lead, for what is termed an overtaker,—that he needs no additional manganese to neutralize the greenish tint. Dr. Faraday observes upon heavy Glass, which in one of his experiments had Flint Glass mixed with it—"The Glass, when finished and cold, was of a deep purple colour: this was immediately referred to the manganese in the Flint Glass, a supposition proved by repeating the experiment with other Flint Glass, and then with Flint Glass of our own manufacture, in which no manganese was used; the latter Glass gave no purple colour; the former, a colour as deep as the first Flint Glass."

cation occurs on the surface of Flint Glass in a species of cloudy, diminutive, white, starry crystals: it is supposed to arise from impurity of alkali. This curious semi-roughed or opaque effect is seldom found in Flint Glass of an open form, but usually on the surface of the inside of a close Glass vessel towards the bottom; the stars are much more minute in Flint than in bottle Glass, and no acid or alkaline application will remove it when the Glass has become cold. If its existence be noticed before the workman has finished the partially devitrified piece of Glass in hand, it may be remedied by thoroughly remelting the Glass sufficiently long, until the partial opacity is dissipated. This defect very rarely occurs when the American subcarbonate potash has been well purified; whereas, it is often caused by the use of the Birmingham ashes, most probably from their not being sufficiently free from sulphates or muriates. In specimens of old Venetian Glass, (without lead,) the interior surface of a vase is often found devitrified towards the bottom and centre; should it have but a small opening, a hollow handle may have its interior affected in the same manner, as if it were roughed; whereas, an open foot or lip of the same vase may be perfectly transparent and free from semi-opacity, owing to the remelting of the two open parts; whilst the body of the vase, having only a small opening, or mouth, fails to get heat enough to remelt into transparency the devitrified part.

Annealing may sometimes appear complete in Glass articles that have borne the friction of deep cutting; which, when long after exposed to the influence of the atmosphere, become fractured, as it were, spontaneously. A large quantity of Flint,

or compound Glass, manufactured at the Falcon Works, (of a beautiful topaz tint, coloured by uranium, which became richer in hue by diminishing the usual proportion of lead, and by increasing the alkali,) fractured three months after it was cut. Complaints from purchasers at home and abroad reached the Works, and the whole had to be replaced at the expense of the manufacturer.

Excess of alkali causes continual exudation; the cementing property escapes, entire fracture is the result, and no remedy can check the evil. A piece of ancient light blue Glass, since it came into the possession of the British Museum, has spontaneously fractured, and some parts almost to pulverization; an effect caused by its excess or impurity of alkali.

Formerly, lears were heated by the waste caloric of the furnace; they were elevated about six feet or more from the floor of the Glass-house, to catch the flame and warmth from the top of the furnace flues. This contrivance saved the entire lear fuel; but from the inconvenience and breakage caused by the Glass being taken up steps, and the impossibility of regulating the heat and smoke, it has been long since disused in England. Modern lears are placed a few feet above the floors of the Glass-house, as already described: they not only anneal the Glass better, but the saving of breakage, in comparison with the old system, is found to be considerable, and wholly covers the expense of separate fuel. The amount of breakage in the lears varies considerably: the minimum average may be taken at 2 per cent. upon the manufacture; under unfortunate or bad

management, the maximum of breakage may be calculated at 10 per cent. Next to the duration of pots, the success of the manufacturer depends upon constant attention, and skilful management of the lears.*

COLOURED GLASS.

Dark, massive, coloured Glasses, formerly made in Flint Glass-houses—whether blue, green, amethyst, or other colours, for hyacinth, hock, and finger glasses, or in large cylinders for cutting and flatting into Window Glass—have been almost superseded; the latter by Crown Glass-makers, and the former by lighter or less dense Flint Glass colours.

The introduction of toilet and smelling-bottles has created a demand for light tinted Glasses, particularly for the beautiful semi-opalescent, yellowish-green colour; produced chiefly by the expensive oxide of uranium, mixed with a slight portion of copper, and appearing yellow or light green, just as the rays of light happen to fall upon the unequal substance or thickness of the Glass. This chameleon-like effect is also produced by uranium alone, used as the colouring oxide for gold topaz: it has been much in demand for hock glasses and decanters, and many ornamental articles of glass; but its fascinating peculiarity is lost, indeed, its colorization mostly fades, by candle-light.

The superior purity and refractibility of our Flint Glass is particularly adapted to display the delicacy and beauty of

* Unannealed Glass exhibits the effects of polarization of light; which being a philosophical subject, is not considered sufficiently practical to come within the plan of this work.

these light tints, and gives a decided superiority to English over foreign Glass. Dark colours are not used *en masse* as formerly, owing to a great loss of light, and apparent shadowy blackness, which is avoided by the modern practice of casing Flint Glass with one or more thin coatings of intensely coloured Glass;*—whether of blue from cobalt, green from iron and copper, ruby from gold; or any colour, made from other suitable oxide of metal.

The density of the colour may be varied—darker or lighter, according to the quantity of colouring oxide used, but it is indispensable that the oxide should be perfectly pure; and the various Glasses, whether transparent or opaque, requiring to be welded, or cased, upon each other, in one homogeneous mass, should be of the same specific gravity; therefore, in mixing, where a large quantity of colouring oxide is used, less lead must be employed, so as to equalize the composition, and render uniform the contraction and expansion of the various layers of Flint and Coloured Glasses.†

The Glass-maker must be ever on the watch for these essential conditions, or great losses will occur in the operation

* See the manipulatory explanation of Cased Glass, termed by the French, Double-Triple, &c.

† The artists of the middle ages leaded their beautiful tints of blue, red, yellow, amethyst, and green, into windows, either thicker or thinner, of solid or cased Glass, as the required effects suggested. They also cased a greenish glass with transparent dark colours, occasionally cutting through the coloured casing to show white alternately, and staining with yellow the white parts thus cut out of the colour. Modern Glass-makers produce as fine colours as those of mediæval manufacture, but time having slightly dimmed or decomposed the surface of many of the fine old windows, a rich subdued beauty of colorization is produced, that cannot be imitated in new Glass.

of cutting. The colours for casing should not remain above two weeks in the pot without being ladled out, and mixed with fresh batch, oxide, &c., as the specific gravity becomes altered by too long exposure to heat, and the Glass injured by evaporation of some of the materials. The severe friction of stoppering is very apt to break cased Glass, unless stopped after cutting; by this means, much of the danger is avoided, especially in single casing. The greater part of the coating being removed by cutting through the exterior, in forming the ornamental pattern, the unequal tension of the two glasses is almost wholly prevented.

It is said that the French first used violet Glass for ripening grapes, and for other horticultural purposes. The rationale adduced was, the partial exclusion of the calorific solar rays, and the greater encouragement of the chemical rays. The experiment has been tried upon a large scale, near London; but whether owing to the glass being of too dark a colour, or to unskilful horticultural management, it did not answer. French beans and strawberry-plants under this glass grew rapidly, but were long, spindly, and tremulous; and not appearing likely to come to perfection, the coloured Glass was removed from the greenhouse.

The author tried some of the same Glass in a frame, upon a very fine cucumber-plant, with two branches shooting out in opposite directions, each having blossomed and being about to fruit; when the branch placed under this coloured Glass, became feeble and diminished,—both leaves and fruit being very diminutive, in comparison with the other half of the plant, under the usual greenish Crown Glass, which perfected its fruit to a large size, and of excellent quality. The

stunted growth of the portion of the plant under the coloured Glass was, no doubt, owing to the colour being too dense, and thereby excluding too much light.*

The ancients were acquainted with the use of the following metals for tinting Glass, as the analysis of various specimens of Roman and Grecian fragments prove—viz., copper, manganese, and iron; the latter, employed in different proportions and admixtures with other metals, produced a beautiful azure blue, nearly equal to the rich modern cobalt colour. See plate 2, and the following table of analysis by Klaproth:—

	Red Glass.	Blue.	Green.
Sand	162	163	130
Oxide of Lead, Blaoxide	28	—	15
Oxide of Copper . . .	15	1	20
Iron oxide	5	19	7
Alumine	2	3	11
Kalkerede, Lime . . .	3	05	13
	195	186	196
Loss	5	14	4
	200	200	200

The above red and green Glasses are chiefly coloured by

* A very light green is found to answer better than a colourless glass for conservatories; and, by recommendation of Mr. Hunt, author of "Researches on Light," &c., the new conservatories of the Royal Gardens at Kew have been glazed with this description of flat Glass, in order to afford the plants protection against the scorching heat of the meridian sun. A great improvement would be effected by the panes being of an arched form, and placed in such an aspect that the morning and evening rays of the sun would not have a tendency to reflect the rays back again, as is the case with thick flat Glass, in which, when the rays pass through it at right angles, parts of irregular substance act as burning-glasses; whereas, by the above arrangement, the rays would pass in a direct course through the glass; and within, the condensed drip would be effectually carried off by channels on each side of the interior of the frames.

copper, and the blue with iron. The latter dark azure iron-blue was, probably, the produce of the Alexandrian furnaces, at a very early period of Glass-making: it was obtained from iron by the late Mr. James Green, who, so far, confirmed Klaproth's analysis. The specimen of the Egyptian idol, and the lachrymatory vase found by Mr. Banks, at Thebes, in Plate 2, are of this variety. Cobalt was probably not used for Glass colorization till a much later period: the Portland Vase and the Naples Vase (Plate No. 1) have, no doubt, crude cobalt for their colouring base (of the dark rich blue); whether they are late Egyptian or Grecian manufacture, it is difficult to decide.

The foregoing and the following analysis of coloured Glasses are extracted from a work by Minutoli, published at Berlin, in 1836, entitled "Uber die Anfertigung und die Nutzanwendung der Farbigen Gläçer bei den Alten:"

Green.

Silica	0·439
Oxide of Lead	0·357
Oxide of Iron	0·016
Oxide of Copper	0·131
	0·943
Difference	0·057
	1·000

This difference is conjectured to be potash or alumine. Flint Glass manufacturers produce a beautiful red from a mixture of copper and iron, and sometimes accidentally: for instance, when the ordinary metal mixed specially for light green medical bottles, is nearly worked out, it will assume the complementary colour—viz., a ruby red; so that the same bottle will be parti-coloured red and green. The

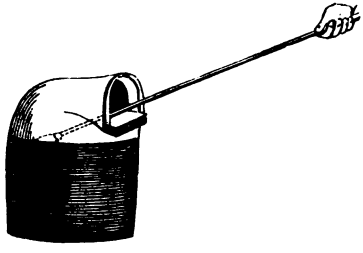
chemistry of colours depends upon a very nice adjustment of relative quantities of carbon and oxygen, as well as of colouring oxide, and of alkali or lead. Uranium is specially affected by an excess of alkali, the colour varying from deep gold topaz to light amber-like opalescent green, as the alkali predominates. The proportion of lead is diminished in either case; and although an excess of alkali extracts most colour from the oxide, it renders the Glass liable to become unhomogeneous, by the exudation of its alkali. It is to be regretted that the specific gravities are not given by Klaproth in his analyses.

Notwithstanding the use of oxide of lead by the ancients in their coloured Glasses and artificial gems and enamels, the lightness of the fragments of their white cut Glass indicates the absence of lead from the constituents of much of the ancient artificial crystal. A fragment in the possession of Mr. Roach Smith, alluded to in another part of this work, and introduced into the coloured Plate (3, fig. 3) can have no lead in its constituents, as its specific gravity is but 2·049; Flint Glass of the ordinary gravity being 3·200, Plate Glass about 2·500, and real crystal about 2·500. No doubt, this relic possessed a large quantity of alkali, probably carbonate of soda or potash, part of which has exuded by lapse of time, leaving the entire atoms or particles of undecomposed silex; thus rendering the glass less compact, of diminished specific gravity, and less conservative. These fragments probably formed part of a Roman white drinking-glass, which, in the days of ancient Rome was scarce, and highly valuable. Had lead formed one of its constituents, the Glass would have been more permanent; the surface would not have been so much decomposed and "crazed," as it is technically termed, leaving more or less

numerous small cracks, extending about half-way through the Glass. Although decomposed on the surface, part of it is rough, as if treated by sand friction, to produce a contrasted effect, such as is employed in our times. The recently fractured parts are quite bright, colourless, and transparent, and melt with the blow-pipe, (but not very readily;) proving the fragment to be artificial, and not real crystal, as at first the author was led to conjecture.

STATE OF THE FURNACE AT THE COMMENCEMENT OF THE WEEK'S WORK.

After the fused Glass has been lowered in temperature, so as to reduce it from a watery condition of fluidity to about the consistence of honey or treacle, it is fit for gathering, as it is termed. Gathering is effected by the workman heating to nearly a red heat a hollow blowing iron, at the larger end; this he places in the pot, in contact with the surface of the metal, to which it instantly adheres; at the same time, the iron is kept in constant rotation by the blower until the requisite quantity of metal is gathered. Should a large quantity be wanted, the first gathering must be taken out of the pot, and cooled by exposure to the air; and when the lump is somewhat consolidated, another gathering upon it may be made from the surface of the metal, and even a third or fourth gathering, until mass enough has been accumulated to make as large an article as the workman is capable of handling. The weight of each gathering is increased in cubical proportions; the first gathering being



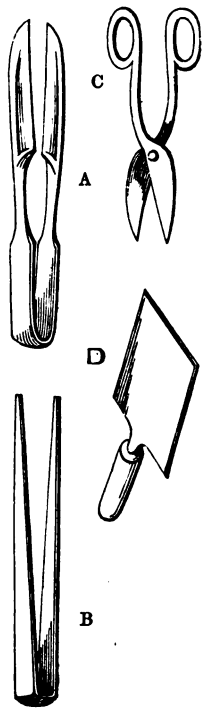
usually about eight ounces, the second four pounds, and the third sixteen pounds. Of course, each time less weight may be taken if required. Accidents to the men by burning seldom occur in a manufactory so as to incapacitate them for work; and when they happen, they are more the result of carelessness than otherwise. A stranger need never feel nervous on entering a Glasshouse in full work, although he might suppose that hot Glass swinging about would often lead to accidents. Visitors are much more likely to receive a blow or a burn by moving about to avoid the men, than if they stood still, and allowed the blowers to swing the glass in their usual way. A few years since, a man was severely scalded, and confined to his house about six weeks, through falling back, after pot setting, into a caldron filled with water, standing in the Glasshouse, into which the remaining contents of the pots had been emptied at the end of the week; this did not occur in the course of his duties, but by what is termed "larking." He was dreadfully scalded, but not burnt with the fused Glass. A pump being in the Glasshouse, cold water was abundantly poured upon the scalded parts, the man was carried home, and attended by a skilful medical man; and after several weeks of suffering, he recovered, and returned to his work.

MANIPULATIONS.

The manipulations of Glass-making may be divided into four principal operations—viz., 1st, blowing and making by Hand; 2nd, in Moulds; 3rd, a more recent introduction from North America—viz., pressing in moulds by Machinery; and 4th, Tube-drawing. When these have been delineated, the Curiosities of the Ancient and Mediæval Manufactures will follow.

TOOLS FOR MANIPULATION.

Glass-makers' tools are but few in number, and extremely simple. The pucellas, A, is somewhat like a pair of spring sugar-tongs, the prongs resembling the cutting parts of shears, but blunt, and used for rubbing the outside of solid or hollow glass, and pressing it into a diminished diameter, at the same time elongating the parts by the chair-rotating process. This tool does the same duty as the cutting tool of a lathe; but instead of removing chips or waste, (as in the process of reducing the diameter of the wood or metal,) it simultaneously squeezes and lengthens. (See Wine-Glass Chair, at p. 83.) This principal tool is also employed to open or close the insides of wine-glasses, bowls, jugs, vases; and to shape generally the Glass, as it rotates at the pleasure of the workman. The spring tool, B, is a species of tongs for laying hold of half-formed handles, and generally to seize Glass while making. The shears, C, are but strong ordinary scissors, used for cutting off the surplusage of glass handles, and to level the edges of bowls of wine-glasses, &c. Much skill is required to shear a wine-glass: it is held upon the iron by the left hand, and rotated towards the shears, which are grasped in the right hand



of the workman. A well-skilled workman can shear a glass entirely round the bowl at one operation. In Bohemia and Germany, generally, the workmen are said not to be sufficiently skilful to use the shears; but the edges of bowls are blown in the rough, and cut smooth by the glass-cutter when cold, which leaves a flat and unsightly finish, far inferior to the round, smoothed edge of fire-polish after shearing. The battledore, D, is another simple tool that needs no explanation. These, with the compasses and the measure-stick, are the chief tools, except the pontil and blowing-iron, which are very simple instruments: the latter is a hollow tube, (about four feet long,) lessened at the mouth and enlarged at the end, for gathering the metal. The ponty, or pontil, is a solid rod, used to support the Glass while working, when the blowing-iron is no longer needed. The sizes of both these rods are heavier and lighter, according to the nature of the work.

Marver.

The marver, L, (a corruption of the French *marbre*, marble being formerly employed,) is a slab of cast-iron, about one

inch thick, with a polished surface, placed upon a wooden stand: upon this slab, the lump of glass is rolled to give it a regular exterior, so that the result of expansion by blowing may be uniform in thickness of metal.

M

Glass-maker's Chair.

The Glass-maker's chair, M, is used chiefly by the workman, although occasionally by the servitor and footmaker. It consists of a flat seat of timber, about ten inches wide, each end being fixed to a frame, connected with four legs and two arms —the latter upon an incline. An edging of wrought iron is screwed upon these inclined planes, for rolling the blowing-iron, with the hot glass at the end of it, backwards and forwards with the left hand; thus causing the rotatory motion of a pole lathe, while the right hand, with the pucellas, gives the requisite form.

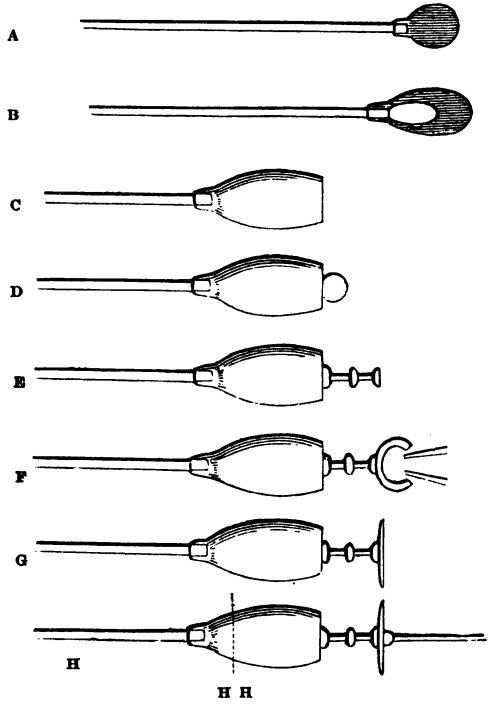
MANIPULATORY PROCESSES.

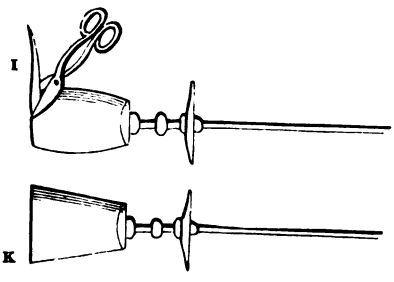
BLOWING AND MAKING BY HAND.

We will now attempt to describe a few of the manipulations of the Glass-blower, beginning with a wine-glass, which will explain also the mode of manufacturing a goblet, and nearly all vases or articles having three pieces—viz., a bowl, stem, and foot.

WINE-GLASS IN THREE PIECES.

A, is the ball of hot Glass, which adheres to the hollow blowing iron, B; and this, after being rolled on a polished cast-iron slab, called a marver, L, and expanded a little, in preparation for the bowl of the wine-glass, C, further shaped, has the end rubbed with the battledore, to flatten it. D,

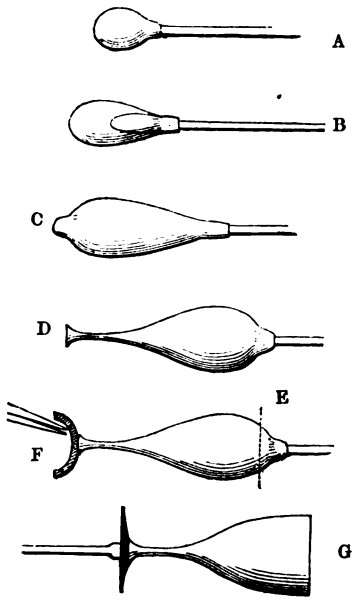




is the same as C, but with a solid ball adhering to the flat part of the bowl; this being a separate gathering, out of which the stem has to be lathed, or shaped, by the tool called pucellas, as E, while it is rotating up and down upon the inclined planes of the Glass-maker's chair, which serves as a lathe. The stem is thus shaped ready to receive the foot. The moment the Glass gets hard by cooling, the rubbing of the pucellas must be discontinued, or an excoriated surface will be the consequence. F has the globe attached to the stem, which is afterwards opened and flattened by the pucellas into a foot, while lathed, or rapidly rotated, as G, on the arms of the blowing chair. H is the same, with the iron pontil adhering to the foot by means of a small piece of gathered glass. The pontil secures the whole preparatory to its being whetted from off the bowl, and released from the blowing-iron at the dotted line, H H, by the touch of the cold pucellas, contracting and slightly fracturing the Glass, which is subsequently cracked through the entire circumference by a smart blow of the pucellas. I, is the bowl under the operation of shearing, so as to make it perfectly even, and fit it for the flashing and finishing, K, which is finally knocked off for annealing from the end of the pontil by a sharp blow.

WINE-GLASS, GOBLET, OR ALE-GLASS, IN TWO PIECES.

Usually, Wine-glasses are made in three pieces; those in two pieces, like the following, have the stem drawn out of the bowl. The first gathering is as usual, A; it is then expanded, swung out, and elongated, as B; from the thick part, C, at the bottom of the bowl, the stem is drawn out with the pucellas while rotating, until it gives the form, D. Of course, during the drawing, it has to be rubbed by the pucellas on the inclined plane of the blower's chair, and rewarmed as often as necessary; when whetted off at the dotted line, E, it is prepared for shearing, as sketched in the former diagram; so soon as the foot is added and opened, as F, and sheared, the bowl is flashed and finished, as G. This form is often adopted for hock and claret glasses. When made very slight, the stem is so attenuated as to be scarcely thicker than a straw.



Between every operation, as before described, the Glass must be submitted to a fresh heat in the mouth of the pot, that the parts required to be shaped may be pliable, soft, and easily impressed by the pucellas. The re heating is also essential to the welding of one piece to another—viz., the stem to the bowl, and the foot to the stem. After the bowl is

sheared, it is re-heated and softened: this is done by rotating it with rapidity in the pot-hole, occasionally withdrawing it, to take into the bowl comparatively cool atmospheric air; again bringing it near the mouth of the pot, so that the expansion of the air within the bowl, the centrifugal force of rapid rotation, technically called flashing,* and the final skilful throw, may give the finished form. A little help may be required from the tools, the use of which, however, should if possible be avoided. The charred wooden tool only must be used, in case the flashing of the bowl should throw the glass out of form. To make a number of wine-glasses free from tool marks, and exactly of one uniform size, &c., requires the workman, or chief, to be of superior tact and skill, supported by an excellent servitor and footmaker.

MODE OF PAYMENT, DIVISION OF LABOUR, ETC.

Before entering into further details of Manipulation, a few explanations relative to the system of paying the workmen, their customs, &c., may be requisite.

The productions of Flint Glass works, in their varieties and divisions of labour, are somewhat like that of a well-conducted farm, on the four-course system, yielding its due proportion of cereal and leguminous crops alternately. Flint Glass works, to be profitable, cannot yield the whole of the product of

* This is but a modification of the flashing process, fully described and illustrated by G. R. Porter, Esq., of the Board of Trade, author of Treatises upon Flint, Crown, and Plate Glass, "Lardner's Encyclopædia." (See Crown Glass, page 185.) Much valuable information may be gathered from the perusal of the whole of the articles on Flint, Crown, and Plate Glass, particularly bead-making, and many other topics not referred to in this work.

the finest quality, any more than a farmer can grow wheat to the exclusion of every other produce; and whoever makes that attempt, will, in the end, find out his error. A ten-pot furnace, filling nine pots weekly, besides overtakers occasionally, (the tenth being an empty pot for the castor-hole workman,) may employ five chairs of workmen, changing alternately every six hours, day and night; there being five chairs at work, and five chairs at rest.

The four-chair system is, however, the mode usually adopted —viz., the first is termed the castor-hole chair, consisting of workman, servitor, footmaker, and boy, for making large goods, such as carboys, and large show-rounds for the chemists' windows, milk pans, handled quart and pint jugs, decanters, semicircles, for roughed lamp shades, &c., Tall or muscular men are employed in this department; as occasionally, goods of thirty or forty pounds weight of Glass will require great power to work into form, the leverage of the blowing iron giving additional weight to the article under manufacture. An empty pot, heated with dried beech-wood, is used by the workman at the castor-hole for re-heating the Glass.

The second chair consists of a workman, servitor, footmaker, and boy, for making fancy articles, and goods required for cutting—viz., toilet and smelling bottles; also tube-drawing in all its operations, for barometer, thermometer, and steam guages, as well as chemical apparatus of small size, &c. The Glass for these purposes is re-heated at the mouth of one of the pots containing fluid Glass.

The third chair, consisting of workman, servitor, footmaker, and boy — is almost entirely occupied in making

wine-glasses, goblets, tumblers, lamp-chimney glasses, and a few other miscellaneous articles. This department, and the first and second chair, require workmen of considerable tact and skill.

The fourth chair does not need the skilled workman of the three former; the men are paid inferior wages, especially as their productions secure less remunerative prices; they, however, require to be remarkably active. One finisher and two blowers, with a boy to keep the mould warm, (with lumps of hot glass,) and another boy as taker-in, are requisite. Thus, phials are re-heated for forming the brims, by a plus pressure of flame proceeding at once from the furnace.

The above four sets of workmen, with a teazer and lear man, changing every six hours, constitute the complement for one furnace; four sets being at rest while other four are employed. Some manufacturers dispense with the bottle-chair, and have in place of it another wine-glass chair, or such substitution as best suits their particular trade.

Glass-blowers have arrangements as to their classes and modes of operation, probably unlike any other branch of trade, being divided into four different coteries, or "chairs," as they are technically called; three of each having their chief —viz., first, a gaffer, or workman; the second, a servitor; and the third, a foot-maker; the latter usually earns about half the wages paid to the chief, and the servitor receives an intermediate amount. The boy, or taker-in, is paid separately, but also by the piece, according to the earning of the chair. Three of the chairs are thus manned.

Boys of ten years old, after being three or four years takers-in, and availing themselves now and then of the opportunity

of a little practice, (by stealth or favour of the workman,) become qualified as footmakers. The mode of reckoning the piece-work of Glass-makers is peculiar. The "move," as it is technically called, is a nominal period of six hours; and the payment is proportionate to the number of articles supposed, by fair exertion, capable of being made in that time by a set of ordinary workmen. The move being fixed at two hundred for small moulded bottles, (for one chair,) and sixty wine-glasses being also considered as the fixed number for another chair, it might be supposed that the two chairs would receive the same remuneration; but the payment would vary, although both quantities are equally a move's work. The wine-glass workman, (or gaffer,) one servitor, and foot-maker, for making the sixty wine-glasses, would receive six shillings per move, and the bottle chair only five shillings between the three men. If, in consequence of superior skill and industry, the chairs made double that quantity in the six hours, which is often the case, they would be paid double the price; and in proportion for any intermediate or lesser number, so that the men are paid proportionally to the quantity manufactured.

The workman, or gaffer, of the castor-hole chair, in full employ, may sometimes earn 3*l.* per week, the second 2*l.* 5*s.*, and the third about 30*s.* per week. Perhaps, the average earnings range from an eighth to a fourth less than these rates. The second, or cutting chair, 2*l.* 10*s.*, 1*l.* 15*s.*, 1*l.* 7*s.*, for the three grades of men; the third, or wine-glass chair, about the same as the second; and the fourth, or phial chair, 36*s.*, 27*s.*, 20*s.*; will be the highest rates of earning. The above

estimates are based upon a calculation of full work, subject to the decrease of from one-eighth to one-fourth, and a still greater reduction, when work is scarce, which is not unfrequently the case.

All the above workmen are thus paid by the piece.

Four chairs of men are capable of working out nine or ten pots of metal weekly, holding each sixteen to eighteen hundred pounds' weight of Glass. One-third of the whole produce may be of the best and finest quality, for chandelier, or table Glass; one third for lamp-chimney glasses, tumblers, chemical apparatus, ink-stands, roughed moons, and other articles, not requiring to be entirely colourless, although equally as free from specks and striæ as the very best Glass; and about the remaining third, and sometimes much more, of the common phials or perfumery bottles. The clearest Glass is always found in the middle of the pot. Of course, the proportion of work will materially vary according to the nature of the demand; and as no manufacturer can regulate proportion, kinds, or qualities demanded, they will sometimes be in excess for the fine goods, or for the coarse, as it may happen. The phial-makers may be almost standing still for work, when the castor-hole workmen have more than can be accomplished in a reasonable time; so that the manager, although he may have plenty of orders in the aggregate, is sometimes at a loss for such orders as will suit the metal, or the chairs, at the moment he may be arranging the work at each change of the move, or every six hours. The manager is also puzzled with minor difficulties: many of the articles by the book numbers, regulating the piece prices, remunerate the workmen indifferently, compared with other articles; he may be driven, therefore, for the

execution of a large number, in a short time, of bad work, (as it is technically termed,) which perhaps all goes to one chair; whereas better work, at the same time, is required to be made by other chairs, of a much more remunerative nature, which is liable to cause a feeling of discontent and jealousy. The manager needs a sense of strict justice, tact, and good humour, to keep himself popular with his men. Decision with promptitude, founded on justice, is always respected and obeyed by operatives, who are never insensible to the *suaviter in modo*, even when accompanied by the *fortiter in re*. A gentlemanly, well-educated manager is, therefore, usually most successful.

WASTE OF GLASS.

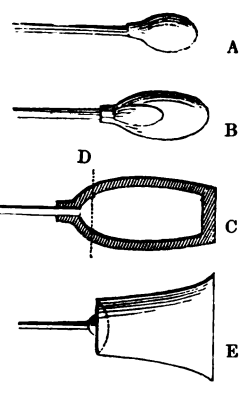
Much waste of Glass takes place in working the fused metal into wares. The greatest waste is incurred by the wine-glass workmen, who scarcely convert into wares one-third of the fused Glass, although they gather from the middle of the pot, where the metal is always most free from striæ, &c. The least waste is occasioned by the phial blowers, who use above two-thirds of the metal they gather from the top and bottom of the pot, where the metal is comparatively impure. The average waste cullet, ladled, or skimmed metal, of the whole of the chairs, is about fifty per cent., or one-half, which is chiefly used again as cullet in the batch of the following week; but every re-melting deteriorates the quality. The loss in broken Glass, in small fragments on the floor of the Glass-House, or elsewhere, is not a very material item; but profits are often seriously reduced by loss of metal through broken pots. The waste, or cullet, &c., is carefully collected and picked,

that the blacks, or parts adhering to the blowing-iron, may be selected for inferior purposes, or for Glass of a light green colour. Loss by waste and casualties may be estimated at ten per cent.

Formerly, under the Excise laws, makers received a very inadequate allowance for waste, which had to be accounted for weekly; and at least seven and a half per cent. loss would have accrued to the manufacturer, unless he had evaded the law, by bringing as many casks of cullet from other parts of the premises, or weighing as much cullet twice over, as was necessary to make up the requisite weight. Excise officers permitted the evasion—certainly a questionable fraud—it being impossible to carry out the Act of Parliament, with justice to the manufacturer, without his resorting to self-defence. These facts were laid before Lord Goderich, then Mr. Robinson, who immediately passed an Act that remedied the evil which so long had been productive of evasion and immorality, without any security to the revenue.

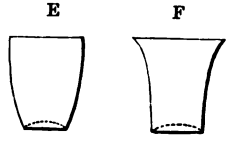
TUMBLER.

One of the simplest articles to make by hand is the Tumbler; but great attention is required in the gathering, to obtain very clear Glass, free from stones, specks, or striæ; also, after marvering, it should be well fire-polished by re-heating or melting out the marver marks; thus removing the numerous irregular indentations generally attributed to bad quality, but entirely due to the carelessness of the workman. To preserve uniformity of weight, substance, and size, needs great experience and attention.



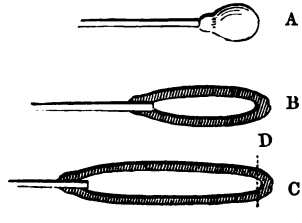
The first and only gathering is A; marvered and expanded by blowing, B; this having been allowed by its own gravity to drop upon the marver, upon further blowing, it resembles C; it is then whetted off at D; and the punty takes the flat end by adhesion E; which is then sheared, flashed, thrown, and finished.

The above supposes a strong flint best pint tumbler to weigh 16 oz. When common light cheap tumblers are required, they are not sheared, and no pains is taken in polishing out the marver marks. They are ringy or wavy, and are called tale tumblers. The barrel shape, E, and beaker shapes, F, are but modifications of the same principle of manipulation.



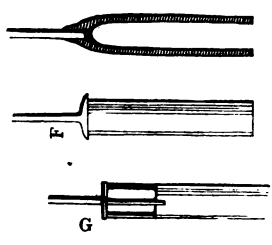
CYLINDRICAL LAMP-GLASS.

Another simple piece of one gathering is the Lamp Chimney, which requires pendulum and circular swinging motions to elongate the shape. The quantity of metal being small and light, the throw must be sharp and decided.



The first solid gathering, A, is expanded and swung out, until it becomes during the blowing as B. It receives more blowing and swinging until it is much longer, as C; a lump at the end is whetted off at the

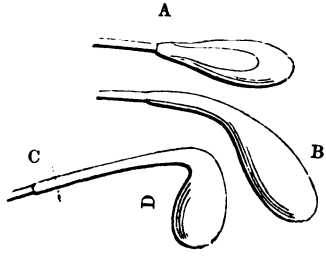
dotted line, D, and opened with the pucellas at E, in which state, when large, it is called a muff; a post, or disk, is then applied at F, that the other end may be sheared, warmed up, and knocked off the post. This forcible knocking-off leaves a rough surface at one end,



which is very liable to cut or scratch the hand in cleaning. A machine is sometimes used instead of a post; this machine is usually a sort of spring cradle at the end of an iron rod, which clips the chimney two to three inches from the bottom, avoids the use of the Glass disk, and prevents the ragged edge, but it is apt to ovalize the chimney; it is not, therefore, much used in Glass Factories. (See G.)

RETORT.

The Retort requires much skill in making the weight small in proportion to its size, and needs sharp swinging and extreme care that the bent part between the quill and the body of the neck (D) should not get too contracted, it having at that point always a tendency to collapse while blowing: A is the gathering, which after being well swung and blown, is as B, which is required, while being blown, to be raised in the air, allowing the body, by its gravity, to bend the part D over a bar. On being further blown, it is whetted off at C.

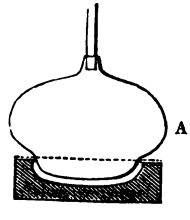


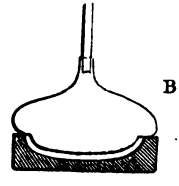
BLOWN-OFF DISHES.

Blown-off (dishes, salts, &c.) is a term well known in the trade. Nearly all dessert dishes, especially those of an oval or square form, are made upon this principle. An oblong dish, of ten inches long, weighs about six pounds, and requires two or three gatherings of metal. When it has been well rolled and flatted into a crude square or other form upon the marver, the workman ascends the chair, and presses it into a brass mould previously placed upon the floor; urging the pressure by blowing, lifting it up repeatedly, and again, as it were, stamping it into the mould; and at last, increasing the inflation from the lungs, and greatly expanding the upper part of the dish called the blow-over, till it becomes so thin at parts as sometimes to explode. A piece of wood is used to knock off the lower part of the overplus, leaving the dish, of considerable substance, which is then turned out of the mould for annealing.

SCOLLOPING OR CUTTING.

The above mode of blowing-*off*, as (A) distinguished from blown-*over*, (B) was of importance during the Excise laws, as it prevented duty being paid upon waste Glass; the plan is still practised, and with advantage. Blown-over, B, is similar to A, but less expanded upwards; the surplusage is, therefore, thicker, and must be flown off by the glass-cutter when cold, which incurs great risk. Whether dishes are to be cut or only moulded, the rough edges must, when annealed, be carefully pinched off, and shaped by the Glass-cutting wheels, preparatory to being finished in scollops, &c.

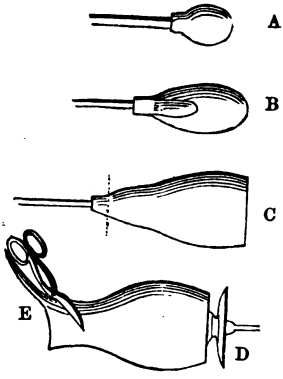


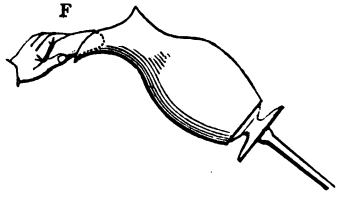


HANDLED JUG.

Next to welding rings, putting on handles is interesting to a stranger. Handled goods require very careful annealing, and the breakage often takes place at or contiguous to the handle, although the blow may be given elsewhere; great risk is, therefore, incurred in cutting.

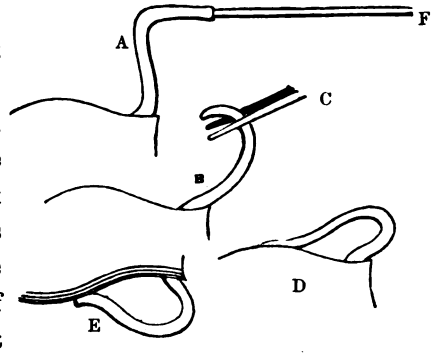
For making a quart jug of four pounds weight or more, it is necessary to gather a ball of solid glass of eight or sixteen ounces weight, as A. When it has cooled sufficiently, (technically called chilled,) the full quantity may be obtained by the second dip or gathering, which has to be marvered and blown as B; and, after swinging, re-warming, and shaping with the battledore, the form somewhat approximates its ultimate shape, C. The foot is then added and opened, as D; the punty iron is next stuck to the middle of the foot, and the mouth re-warmed and sheared, as E. Again re-warming the mouth, it is opened by the pucellas, and a piece of hollow Glass, previously prepared, F, presses down or shapes out the lip; whilst the temperature being below welding heat, the glasses do not adhere. The lip or spout is then regu-





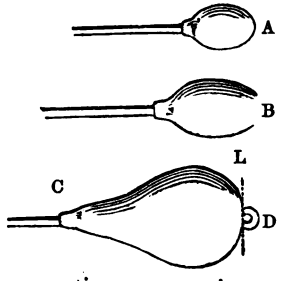
lated with the pucellas. The whole is re-warmed and made ready to receive the handle, which is prepared by the servitor, and consists of a long piece of solid soft Glass, A. It is allowed by its own gravity to fall and to weld on the upper part of the neck of the jug, B, exactly opposite the lip; great care being taken that the part receiving the handle is free from dust, or the sulphur which arises from burnt coal or damp wood, which would render the adhesion incomplete.

As soon as the handle welds firmly, it should be separated from the iron, F, sheared through; and the workman instantly takes it with the pucellas, C, and throwing it a little back, and then forward, he slowly draws it back again, and gently presses the other end upon the lower part of the neck of the jug, D. When this part likewise adheres, the handle is shaped by rotating the jug and distending the handle by centrifugal motion, as E. The handle side is then turned upward, and the pucellas gives the finished form to the handle. The jug is, lastly, warmed all over, and placed in the lear for annealing. The adhering parts of the handle (technically called sticking parts) need gently pressing to assist the welding; and at each sticking operation, quick rotation of the jug and re-warming are essential.



FRENCH LAMP-SHADE.

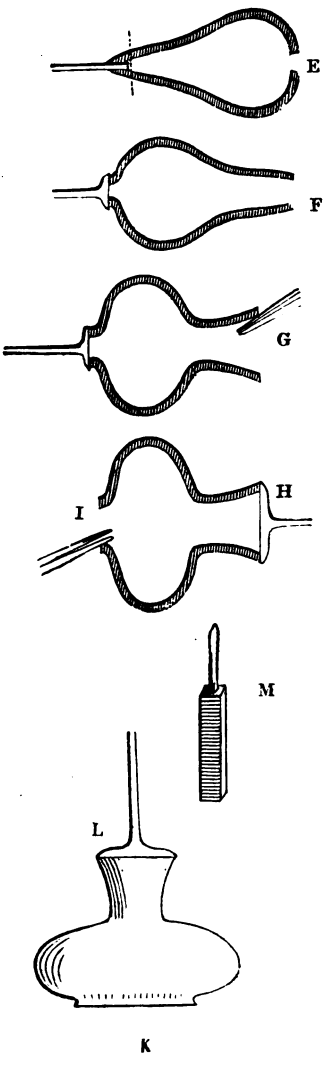
The following is another illustration of the process of making by hand. For many years, the trade in French Lamp-shades, or semi-circles, has formed a large proportion of employment for the castor-hole chair. The fitting part of the shade is usually about ten inches, and the swell of its vase-like form, about twelve inches, diameter: these are too large to be made at other chairs, as they warm at the mouths of pots holding metal, the openings of which seldom admit of articles exceeding six or eight inches. The mouth of the castor-hole pot is about twenty-four inches, which is diminished at pleasure, by rolls of Stourbridge clay, diminishing, circle upon circle, until the required size of the opening is attained. The French enlarge or lessen the opening of the castor-pot by consecutive rings of burnt clay fitting upon each other, a much superior and cleaner mode of effecting the same object. A few years since, this plan was tried in our own Glassworks, but was soon discontinued.



The footmaker takes a solid lump of Glass, A, which, after a second gathering, will weigh about four pounds, B. The blowing-iron is stronger, thicker, and of a larger bore, than those used by the other chairs; and the blower, by adroitly rubbing it on the marver, and blowing simultaneously with the rotating motion, approximates it somewhat towards its ultimate form, C. The knob at D is

knocked off, leaving a small opening, as at E.

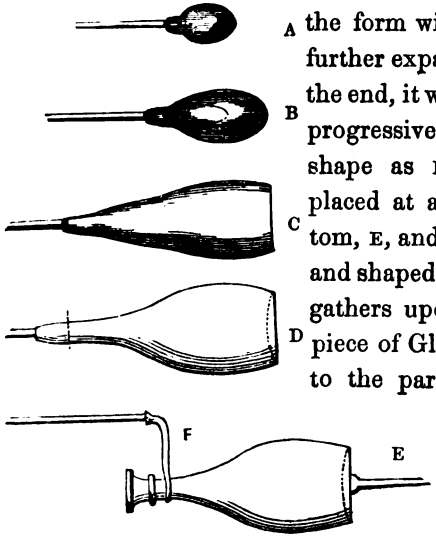
During the progress of the work, at nearly every change of form, the Glass has to be re-warmed. Afterwards, the piece of Glass, F, is made to adhere to a small disk; and softened by the heat of the furnace through the castor-hole pot, (assisted by the heat from the flame of small pieces of dry beech wood,) the opening is enlarged by the pucellas, G, and the neck is formed, which is made to adhere to the post, or disk, H. The other end, I, is partly opened by the pucellas, and partly expanded to its ultimate shape, K, by the flashing process: this consists of retiring it from the heat, to take in comparatively cold air; and afterwards advancing it towards the heat of the castor-hole, which, expanding by rarefaction of the air, accompanied simultaneously with a sharp trundling or rotatory motion, the globe form becomes more



or less widened, at the pleasure of the operator. The Glass disk, L, is then released from the neck, by a dexterous tap with the chest knife, M,* and the Lamp-shade is finished. If the blow be too sharp, it is apt to chip the brim, and occasionally to destroy the shade. A wooden peel is used to convey the perfect article to the lear for annealing.

RINGED DECANTER.

Making a decanter is a simple operation. The gathering is as usual, at A; when swung out, the form will be as B; upon being further expanded, and battledored at the end, it will be thus, C. The next progressive operation will leave the shape as D. The ponty iron is placed at and adheres to the bottom, E, and the mouth is warmed up and shaped. Another workman then gathers upon a ponty-iron a small piece of Glass, which is dropped on to the part where the ring is required, F. By rotating the decanter, the entire circle, or ring, becomes welded by con-



* The chest knife is a cube of steel, having four acute angles and a handle, about twelve inches total length; it is principally used for knocking off, into the chest, the waste metal that adheres to the blower's iron, hence technically called chest metal.

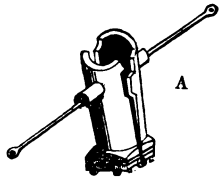
tact, and its surplus is tapered, and torn suddenly away. The whole is reheated, and the pucellas are then pressed upon the ring of the decanter while rotating upon the inclined plane of the chair. Pucellas for forming rings differ from the common tools, in having two dies affixed to the prongs; which dies, being pressed upon the ring while hot, give the required shape and size. A second and a third ring are then added, after reheating the decanter, as F, by repeating the process; and by the punty affixed to the bottom, the brim may be finished, and the rings well melted in, to insure safe welding and annealing.

MOULDED BOTTLES.

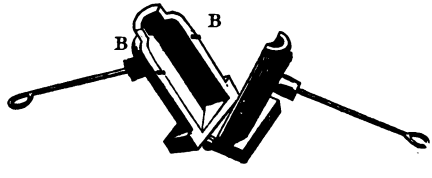
The process of moulding common apothecaries' phials, and the principle on which nearly all perfumery bottles, as well as common wine-bottles, are made, cannot be more satisfactorily explained than by the well-informed author of the article upon Flint Glass in the work entitled "*Days at the Factories*"* We first saw," says the writer, "some four-sided perfumery bottles made. A man took a hollow iron tube, about five feet long and half an inch in diameter, and dipping one end into a pot of melted Glass, collected a small quantity at the extremity. The Glass appeared like a projecting lump of red-hot iron, and, from its consistence (between that of treacle and of putty), was just able to be retained on the tube. He then rolled the Glass on a flat plate of iron, thereby giving it a cylindrical form, and

* "Days at the Factories." By George Dodd. C. Knight.

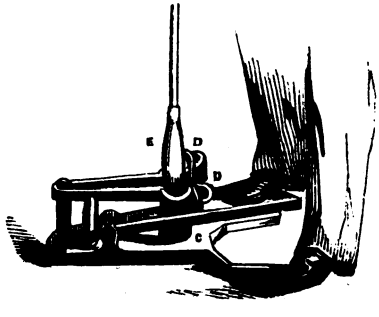
pinched a part of it, by means of a small instrument, to form the neck of the bottle. He next inserted the end of the tube into a small brass mould lying on the ground, shut up the two parts of which the mould consisted, and blew through the tube. This double operation produces a curious effect; for while the air from the lungs, passing through the tube, makes the mass of Glass hollow, the mould at the same time imparts to it the external form required. The mould being opened, the Glass—now in the form of a bottle—was withdrawn."



The mould A, as sketched, is termed an open and shut mould, and is generally constructed in two exact halves, (connected with a bottom hinge,) which in a round bottle shows two seams or lines, caused by the two sides of the mould not shutting quite closely. The seam is not unsightly in the square form, as the joint takes place at two of the corners, B.



Many manufacturers prefer moulds for round bottles, of one piece for the body, C, and two pieces for the neck, (D D,) by which the seam down the body is avoided; although two slight seams are observable in the neck. E is an expanded ball of



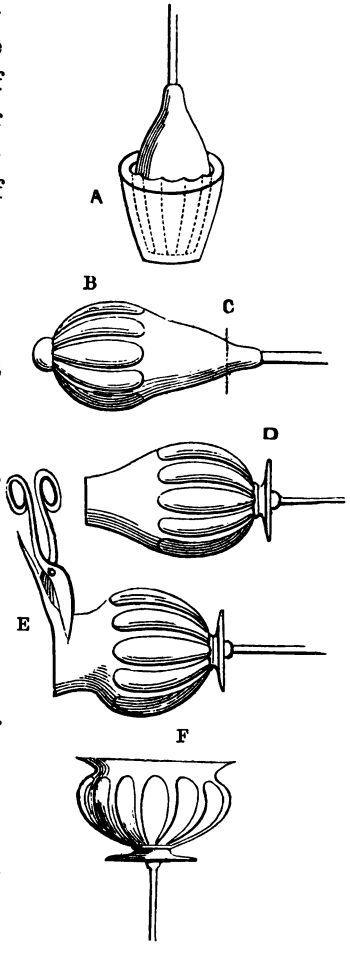
metal just entering the mould, which instantly takes its form by sharp blowing; the brim is then finished, as before explained, by the gaffer, or workman, at the chair. This is an expensive principle of mould making; but it decidedly gives a more polished surface to the bottles, and produces excellent apothecaries' phials of uniform size and capacity. The phial cannot, however, be made of a perfect cylindrical form, as it needs the upper part of the mould to be a slight degree larger than the lower, to allow of the delivery of the bottle from the mould. It is closed by a treadle acting upon two levers with inside springs, which again open the mould when the foot is removed.

All bottle moulds, while working, require to be kept nearly at a red-heat, by means either of a small furnace, or a piece of hot Glass, which is held by a lad inside the mould upon a punty-iron, during the intervals it may be unoccupied by the two blowers. Without this precaution, the surface of the bottles will be *ruffled*. The heat of the moulds is essential to the polish; but care is requisite to keep the metal moulds, whether brass or iron, a little below red heat, or the Glass will adhere to them.

MOULDED ROMAN PILLARS.

Moulded Glass, as recently introduced by the English manufacturer, owes its refractive and cut-like effect to its inequalities of substance — the interior having no indentations to correspond with its exterior projections. It requires, in addition to the usual Glass-maker's tools, only a metal mould of about one-third the size of the object to be manufactured. The metal is first gathered upon a rod in the ordinary manner, except that the first gathering should be

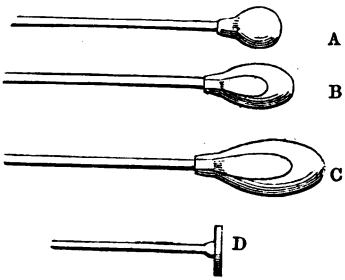
allowed to cool to a greater degree of hardness than usual; the second coating should be pressed into the mould, A, as hot as possible, that the exterior coating only shall be acted upon by the pressure of moulding, and that the interior shall preserve its smooth circular area. When about half formed, the projecting parts, B, have a centrifugal enlargement given to them by a sharp trundling of the iron at, or immediately after, the moment the workman is blowing; during the re-heating process, the piece is separated at C, has a foot welded to it, and is re-warmed, as D; sheared, as E; and when finished, by flashing, shaping, &c., as F, is called patent pillar-moulding. The fire polish is given to it by frequently re-melting the surface of the Glass, after it leaves the mould. A little cutting or scolloping makes this refractive moulding still more ornamental; but, though it much resembles cutting, (as to its round pillars), it is inferior where sharp angles are required.



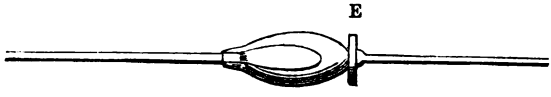
Pillar moulding is, however, one of the greatest modern improvements; and is used advantageously for lamp pedestals, chandelier work, toilet bottles, salt-cellars, &c., at very moderate cost. This was supposed to be a modern invention, and introduced by the late Mr. James Green, as such, a few years since; but, in some Roman specimens, recently exhumed in the city of London, and now in the possession of Mr. Roach Smith, it is proved beyond doubt that these projecting pillars, and the mode of their manipulation, were well known to the ancients. (See coloured Plate 3, fig. 2.)

CANE AND TUBE DRAWING.

The ductility of Flint Glass is strikingly exhibited in the process of Cane or Tube-drawing, which is extremely simple, and depends so much upon tact and adroitness, that it is a matter of surprise how an approximation to uniformity of size and bore can be attained. A solid ball being gathered on the end of the blower's iron, A, if for hollow tube, is expanded a little by blowing, B; but if for cane, blowing is not requisite: when partially cooled, it forms a nucleus for one or more other gatherings, until the requisite quantity be obtained. Where flat bore tube is required for thermometers, the first ball is flattened by an iron or wood battledore, on the marver, prior to the subsequent gatherings; this ensures a flat bore, although the exterior of the tube is round. The ball is then elongated by

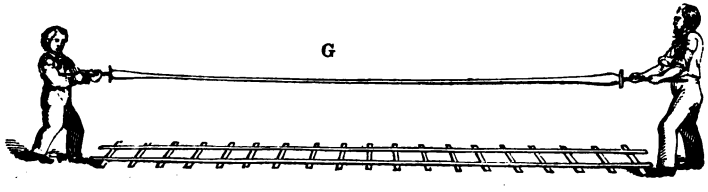


swinging, C, and the further end of it is chilled by dipping it into cold water. A workman then, having prepared a disk of hot Glass, D, called a post, places it vertically as near the ground as possible, to receive the ball from the chief workman; he next ascends his chair, or an elevation, so that the hot Glass may by its gravity be dropped upon the post below, to which it adheres by partial welding, E. The chief workman then



descends from his elevation; the drawing now begins—each workman constantly receding from the other: at first, the suspended Glass between the two rods assumes (at a red heat) the form of a parabola, F; but, as the tension proceeds, the

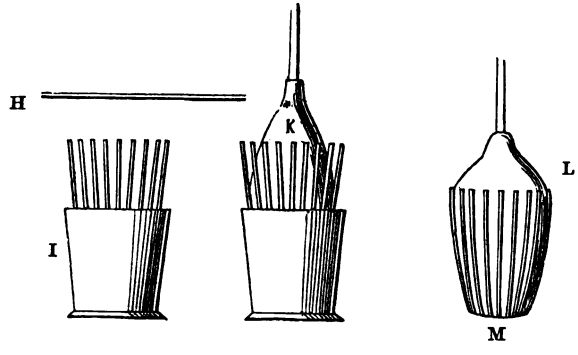
workmen are continually rotating. Some parts are cooled by fanning with the hat of an attendant boy, to ensure uniform elongation, till the cane or tube is drawn to a length, sometimes of from sixty to seventy feet: as the metal cools, the tube ceases to rotate, and it assumes, by continued tension, nearly a straight line, G; except at the extreme ends, it is



nearly of one uniform bore, diameter, and substance; and whatever may be the diameter of the tube, the bore and substance will always bear an exact relative ratio to each other. Lastly, it is deposited upon the wood rounds of a ladder, and requisite lengths are whetted off by the cold iron, or by a steel file.

VENETIAN FILIGREE GLASS.

As Glass-house manipulators, the Venetians were pre-eminent; they produced, if not the most elegant, at least extremely curious, work. In the manufacture of Glass beads, the Venetians have no rival, their price being far below English competition. The Venetian glasses, termed "filigree," have recently been made in France and Bohemia, and a few specimens in England. Before ornaments or vessels can be blown, small filigree canes* with white or variously coloured enamels, must be drawn by the following process:—Pieces of plain, coloured, or opaque white cane, previously drawn as explained above, are first whetted off to the required lengths,



* "Cane" invariably means a solid stick of Glass; and "tube," hollow.

H, and then put into a cylindrical mould, I, with suitable internal recesses; and both cane and mould are thus submitted to a moderate heat. The selection of the colour of the canes depends upon the taste of the manufacturer: two to four white enamelled canes are chiefly used, alternately, with about half the number of coloured. The blower then prepares a solid ball of transparent flint Glass, K, which being deposited in contact with the various canes, at a welding heat, causes them to adhere. This solid ball is then released from the mould, as L, is reheated, and marvered, till the adhering projecting ornamental canes are rubbed into one uniform mass; the ball is next covered with a gathering of white glass, which must then be drawn to any size and length that may be required, by the same process as before described and illustrated. Should a spiral cane be preferred, the pucellas holds the apex, M, in a fixed position, while the ornamental mass, still adhering to the Glass-maker's iron, is revolved during the drawing, till the requisite twist is given. Where vases are formed of alternately coloured and enamel filigree canes, the above process is repeated, and the usual mode of blowing and manufacturing is followed; but the ball, K, must be hollow instead of solid, so that the filigree canes become, by marvering, &c., amalgamated with the flint Glass ball, and expand with it in its progress of manufacture.

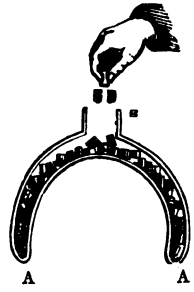
VENETIAN BALL.

The Venetian ball is a collection of waste pieces of filigree Glass conglomerated together, without regular design: this is packed into a pocket of transparent Glass, which is adhesively collapsed upon the interior mass by sucking up, producing out-

ward pressure of the atmosphere. Some of the ancient specimens have apparently been decomposed on the exterior, but can be again restored by the Glass-cutter's polishing wheels. (See Plate VI., fig. 1.)

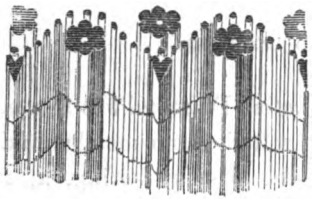
MILLE-FIORE.

The *Mille-Fiore*, or star-work of the Venetians is more regular in design than the ball, but of the same character. It was formed by placing lozenges of glass, cut from the ends of coloured filigree canes, ranging them in regular or irregular devices, and encasing them in Flint transparent Glass. The double transparent Glass cone, A, receives the lozenges between the two surfaces. The whole is reheated; a hollow disk, communicating with the blowing-iron, adheres to the neck, B, and the air is exhausted or sucked out of the double case, as further explained in the cameo illustration. After being rewarmed, it becomes one homogeneous mass, and can be shaped into a tazza, paper-weight, &c., at pleasure.



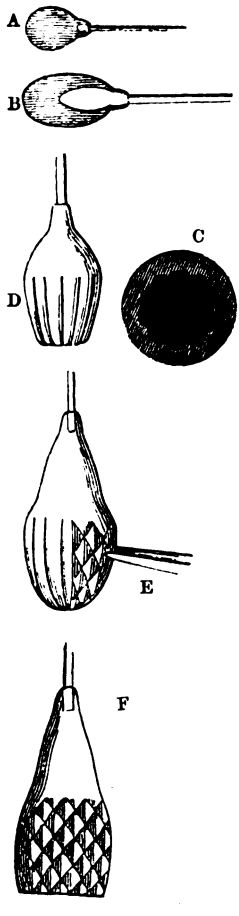
MOSAIC WORK.

The Romans, and possibly the Greeks, formed beautiful arabesque and other designs of Mosaic Glass: many of these are of minute and accurate execution, in light colours beautifully harmonized upon a dark ground, formed wholly of threads of Glass. They are ranged vertically, side by side, in single threads



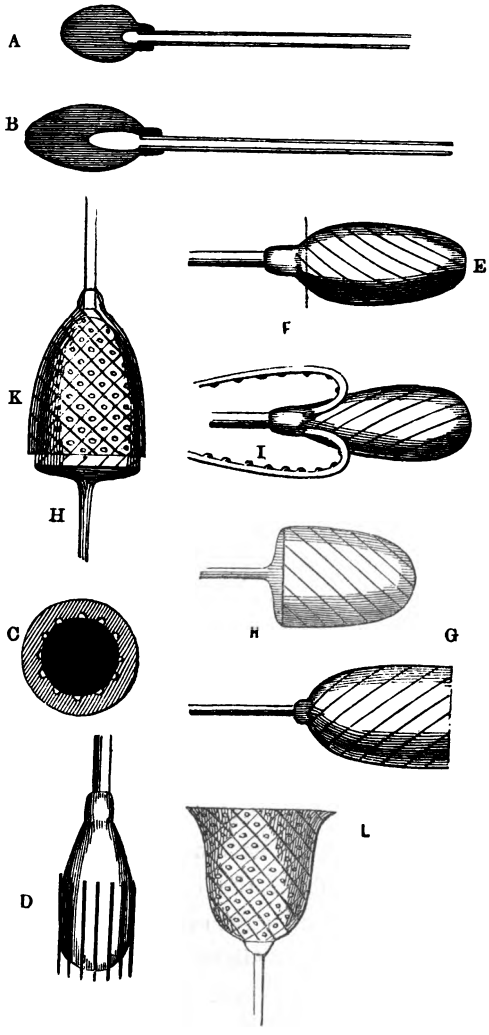
or masses, agreeably to a prefigured design. When submitted to heat sufficient to fuse the whole, the four sides, at the same time, being pressed together, so as to exclude the air from the interstices of the threads—the result will be a homogeneous thick slab, which, if cut into veneers, at right angles or laterally, will yield a number of slabs or layers of the same uniform design; these, it is supposed, were employed by the ancients in jewellery ornaments. Many specimens may be seen in the British Museum. (See coloured Plate III., figs. 5, 6, 7, and 8.) On this principle were executed the pictures of Mosaic Glass noticed by Winckelmann. Ancient pavements were inlaid with small pieces of coloured Glass, some quite opaque, of various tints, put together with cement, in a like manner to the fictile, tesselated pavements. Similarly small pieces of opaque enamel and Glass were also used in great abundance to ornament the fountains of Pompeii; and specimens of this class are continually discovered. This tesselated Glass-work is, however, entirely dissimilar to the above Mosaic, the various pieces not being, as in that, homogeneously united together by fusion. Minutoli, in his "Farbigen Gläer beiden Alten," gives a drawing of three nymphs and a male figure, the latter carrying a water-urn, and the three former wearing coronets of reeds, all in tesselated light green Glass, whilst the entire of the dark green background and yellow figures of the picture, are executed in stone mosaics.

VENETIAN DIAMOND-MOULDED.



The old Venetian Diamond was formed by impressing soft glass in a metal mould, as follows:—the first gathering, A, is solid, and afterwards covered by a second gathering, as B; this is expanded by blowing in the usual manner, and being rewarmed, is blown into the projecting pillar-mould, C, and when further expanded, impresses the Glass ball as D; the pillars are pinched together by the pucellas, E, at equidistant points, into the diamond form, E and F, one by one, until the whole of the projecting straight pillars become diamond pillars. Equally good effects are produced by modern Glass-makers in a more direct manner, by making brass open-and-shut, or dip moulds, so as to give at one operation the entire diamond impression, thus saving the tedium of forming each diamond separately with the pucellas. Some of the old Venetian caraffes, with handles and loose stoppers, have Glass ornaments laid in lines vertically upon the diamonds, pinched and raised up in parts, in uniform patterns, perhaps more illustrative of industry than taste.

VENETIAN VITRO DI TRINO.



The solid ball being gathered, as A, expanded by blowing, and marvered, as B, &c.; the interstices of the interior of the mould of brass, agreeably to the section annexed, C, are filled with small white enamel canes; and the ball of Flint Glass is then blown fully up to the canes, to which it firmly welds, as D. As soon as it has been re-warmed, a workman holds with the pucellas the bottom of the ball, D, while another workman twists the blowing-iron, giving the conical form,

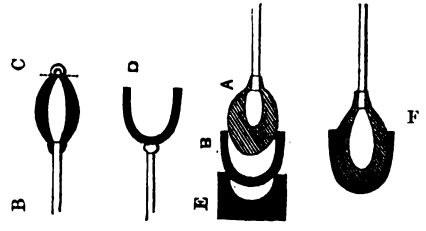
as sketched in E; it is further whetted off at F, opened, as G, and has the projecting canes on the outside of the cup; a Glass disk, or post, being made to adhere to its open end, as H. The inner case of the Vitro di Trino process is thus completed. To make a corresponding outer case, a ball must be formed into a cup or cover, of exactly the same character, a little larger, but turned inside out, as I; which gives the twist the reverse way, and causes its interior canes to project inside the cup, K.

The inner cup, or case, H, is now placed within the outer case, K; and these two conical cases now crossing each other, are, by re-warming, collapsed together, entrapping between each white enamel crossed section, uniform interior air-bubbles, as L; and the two cases, now become one, may be formed into the bowl of a wine-glass, or any other vessel; the disk, H, having been previously removed by a gentle tap of the chest-knife. Upon this principle was made the specimen, in the coloured Plate 4, fig. 1.

CASED GLASS.

The principle of casing a layer of colour upon Flint Crystal Glass, or as many layers or varieties of colour upon each other as may be required, was well known to the ancients who made the Portland and Naples Vases. Only one operation need be explained, as every additional coating is merely a repetition of the same process. Presuming, therefore, that any two or more glasses intended for casing have been mixed of the same specific gravity, to give them the capability of harmonizing,—that is, contracting and expanding equally,—the blower has to gather a ball of solid Glass, intended for the interior layer, in the usual manner, as A, which, in this instance,

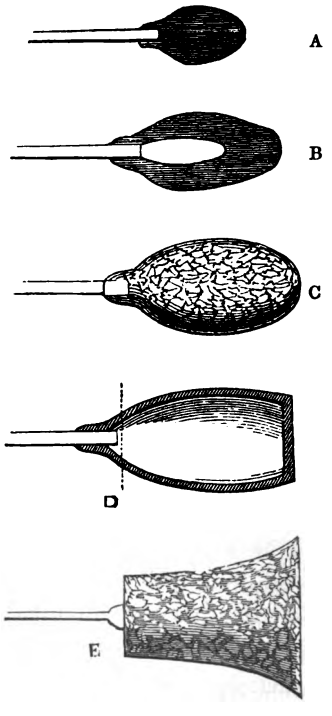
may be considered to be of white crystal Glass. About the same time, his assistant prepares a casing of colour, B, knocking off the knob at C, to open and shape it, as D, somewhat like the bowl of a wine-glass, or the broad-end of a large egg-shell; this is set into a metal stand, E, on the floor, merely to steady the case, or shell, B; while the blower takes the lump of Flint or white Glass, A, and gently blows it



into the coloured case, or shell, B, to which it immediately adheres; and when submitted to the flame of a pot-hole, or, if a large piece, to the flame of the castor-hole, it is found to weld perfectly, as F. If various coverings are needed, as many coloured shells must be prepared as required, and each time melted in by fresh warming, until the entire number are obtained and cased. The whole are afterwards rewarmed, expanded, and shaped into vases, tazzas, or such other articles as the manufacturer requires, by blowing, and the usual appliances of moulds, tools, rotatory motion, &c., as have been explained in former manipulations. If cased coloured Glass for windows be made, the cased ball must be larger, expanded, elongated, and made into a cylinder, or muff, precisely as in optic plate, or a lamp-glass; but in large sheets, after shearing through the whole length of the cylinders, and

flatting them into square panes, in a kiln provided and heated for the purpose.

OLD VENETIAN FROSTED GLASS.



A, is the first gathering; B, the second, expanded by blowing; while at nearly a white heat, it is suddenly plunged into cold water; if immediately rewarmed and blown, the effect will be as C; flatten the bottom, and whet off at D; attach a ponty, as E, and finish the article as usual; but in the latter process, the less heat the better, or it will melt out the frosting.

Frosted Glass, like the *Vitro di Trino*, is one of the few specimens of Venetian work not previously made by the Egyptians and Romans; and not since executed by Bohemian or French Glass-makers. The process of making it, until recently practised at the Falcon Glass Works, was considered a lost art. It has irregularly veined, marble-like projecting dislocations, with intervening fissures. Suddenly plunging hot glass into cold water, produces crystalline convex fractures, with a polished exterior, like Derbyshire spar; but the concave intervening fissures are caused, first by chilling and

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then reheating at the furnace, and simultaneously expanding the reheated ball of Glass by blowing; thus separating the crystals from each other, and leaving open fissures between, which is done preparatory to forming vases or ornaments. Although frosted Glass appears covered with fractures, it is perfectly sonorous.

WELDED COLOURED GLASS.

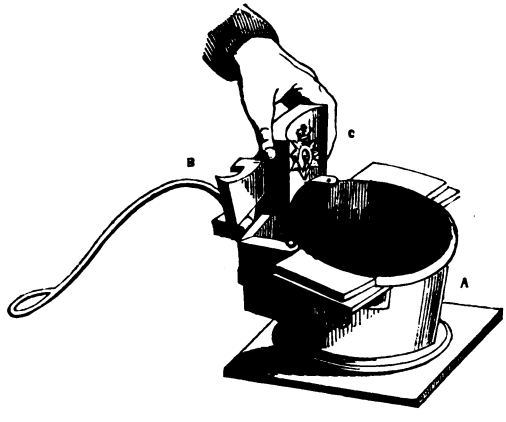
Welding coloured Glass to white or lighter-tinted Glass, for windows, skylights, &c., has been patented by the author. It is effected with detached pieces of dark-coloured Glass prepared by cutting, pinching, or moulding; these are placed in the interstices of cast brass, or iron moulds, previously chased by the die-sinker; and the whole are gradually heated to nearly a red heat. Hot white, or light-tinted Glass, is then cast upon the mould, about the consistency of honey; the entire mould is covered with it, and rubbed with wood, till cold enough for annealing; when it will be found firmly welded to the detached coloured pieces, and will deliver from the mould as one entire mass. Should one uniform tint only be required, the detached coloured pieces are dispensed with; and the rolling or pressing is the same with one colour as with the above various tints; the light and shade being produced, where one colour only is used, by the unequal substances of the tinted Glass having a tendency, in the thickest portions, to exhibit complementary colour.* This

* Rosettes for windows may be pressed at a very reduced price by this process. Mr. Eastlake, Secretary to the House of Lords' Commission, allowed several specimens made at the Falcon Glass Works to be exhibited in St. James's-street, at the first public display of works of art in connexion with the Commission.

principle was first explained by Professor Cowper, of King's College, London.

CRYSTALLO ENGRAVING.

In addition to Cameo Incrustation which was patented many years since, a subsequent patent was secured for taking fac-similes of casts or dies from intaglios, and impressing them upon hollow Glass vessels in intaglio. This plan of Glass engraving has been chiefly adopted where numerous copies of elaborate devices have been required; such as badges of regiments, or arms upon decanters and table Glass. The following is the mode of operating: dust Tripoli, very finely pulverized upon the die or cast; then a larger coating of dry plaster of Paris and pulverized brick-dust, with another layer of coarser plaster of Paris and brick-dust; place the whole under a press, which when screwed to its utmost, allows water to saturate



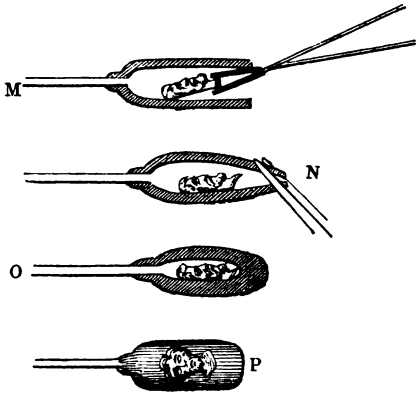
[The above represents the workman fitting the cold, dried, Tripoli-faced plaster cake, into the recess of the mould, as it occasionally requires a little reducing with a file. It is afterwards removed, and brought to a red heat in a small muffle set in the furnace, and placed in the heated brass mould with a pair of iron tongs.]

the pores of the impressed cake; and, when gradually dried, it will be fit for use. A brass mould, A, with a recess to receive the cake, and a hinged leverage to keep it in its position, B, is provided; so that the face of the cake, C, which is then embossed in relief, ranges with the circular form of the Glass vessel intended to be blown into it; and this, being heated to redness, is placed in the recess of the mould. In this state, the ball of hot Glass is introduced and expanded by the power of blowing, till it assumes the exact shape of the mould, and the cake adheres to the Glass. The cake is then released by the lever, and the Glass reheated, with the cake adhering to it, as often as necessary to finish the article, (as usually practised by blowers in ordinary moulded Glass vessels); the cake and Glass vessel being annealed together, with its blow-over, which is afterwards finished by the Glass-cutter. When the Glass is cold, it is released from the cake by its absorption of cold water, and the intaglio impression upon the Glass will be found as sharp as the original die. A cake once used, seldom answers for a second impression. Mr. Tassie had, long before this process was patented, executed on the same principle imitations of small gems in solid Glass, very successfully, which suggested the application of the same invention to hollow vessels.

CAMEO INCRUSTATION.

Cameo Incrustation was unknown to the ancients, and was first introduced by the Bohemians, probably about a century since; and Bas-relief casts of busts, and medals, were entirely isolated by them within a coating or mass of white Flint Glass. The figure intended for incrustation must be made of materials that will require a higher degree of heat for their fusion than the Glass within which it is to be incrusted; these are china

clay and super-silicate of potash,* ground and mixed in such proportions as upon experiment harmonize with the density of the Glass; and this, when moulded into a bas-relief or bust, (in plaster of Paris moulds,) should be slightly baked, and then suffered gradually to cool; or the cameos may be kept in readiness till required for incrustation, for which purpose they should be carefully reheated to redness in a small Stourbridge clay muffle. A cylindrical flint Glass pocket is then prepared, one end adhering to the hollow iron rod, M, with an opening at the other extremity, into which the hot composition figure is introduced; the end, N, is then collapsed and welded together by pressure, at a red heat, so that the figure is in the centre of the hollow hot Glass pocket or muffle. The workman next applies his mouth at the end of the tube, O, while rewarming the glass at the other extremity; but instead of blowing, he exhausts the air, thus perfecting the collapse, by atmospheric pressure, and causing the Glass and composition figure to be of one homogeneous mass, as P.



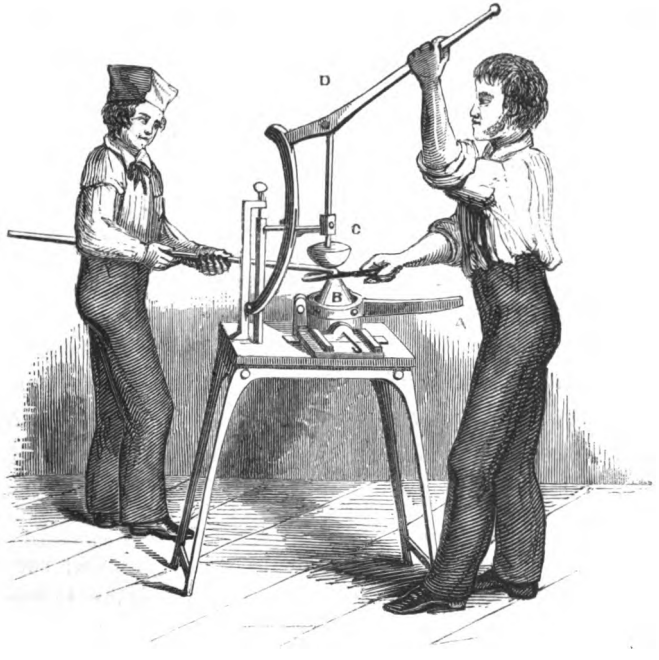
Small bas-reliefs and casts of coins or medals are incrusted in a more expeditious manner, and especially upon hollow

* By super-silicate of potash is meant, sand exposed at a high temperature in a crucible, with a small portion of carbonate of potash, sufficient to fuse it partially, for grinding into an impalpable powder.

Glass vessels, by placing a hot prepared cameo, of the usual composition, upon the hot manufactured vessel; a small piece of liquid Glass is dropped on it, and becomes welded; and, if rubbed while hot, the upper coat of fused Glass will be spread as thinly as possible upon and around the cameo, behind which are driven any air bubbles that may be entrapped; thus completely isolating the device between the two Glasses. These incrustations require very careful annealing.

AMERICAN PRESSED GLASS.

Pressing is a mechanical operation, unknown to the



Pressing Glass.

ancients or the Venetians.* It may be thus described:—a die being prepared, secured by the ring and handle, A, metal is gathered and dropped into it, B, and the matrix, or plunger, C, operated upon by the lever, &c. D, presses the metal into the required form of the article. If an overplus of metal be gathered, it thickens the article throughout; but if too little, it fails to fill up the mould, and is spoiled. This is a rapid mode of reproduction, but great practice is required to gather the exact quantity of metal. The chief condition of success, in getting a polished surface on pressed Glass, depends upon the moulds being kept at a regular temperature, a little short of red heat. The effect is not so good as pillar-moulding, nor does it anneal so well; but it is much less expensive. The interior plungers and the outer die will adhere to the Glass if too hot; and if not at a proper temperature, will fail in producing a clear transparent surface.

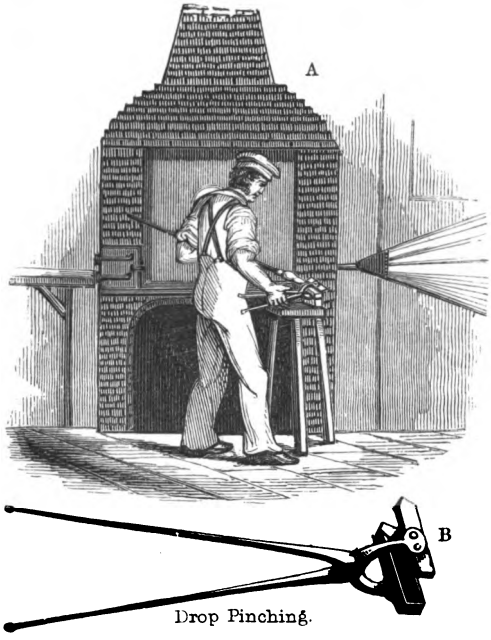
DROP PINCHING.

Pinching by moulds is chiefly used for solid drop-work, spangles, &c. Lumps of Glass made expressly for drop pinching,† when softened sufficiently by a blast-furnace, A, are shaped in twin brass dies, affixed to tongues, B. Arms of chandeliers are pressed also by twin dies, the upper die being fixed to the plunger, and the under one to the bed of a

* Various slabs of coloured Glass, of small sizes, were pressed into metallic dies by the ancients, as proved by the specimens of embossed and intagliated Glass, of various patterns, in the British Museum; but no machinery was used by them in producing any completely pressed hollow vessel or utensil, at one operation.

† A considerable number of the Glass drops used for chandeliers, girandoles, and candlesticks, in England, are pinched from thick tumbler bottoms, or waste glass, causing a variety of tint, and inferior refraction.

powerful leverage press; the metal being gathered as usual, and the power of the press applied. Both arms and drops receive only the crude form; they afterwards require cutting, and polishing on a lead lap, to produce the required brilliancy.

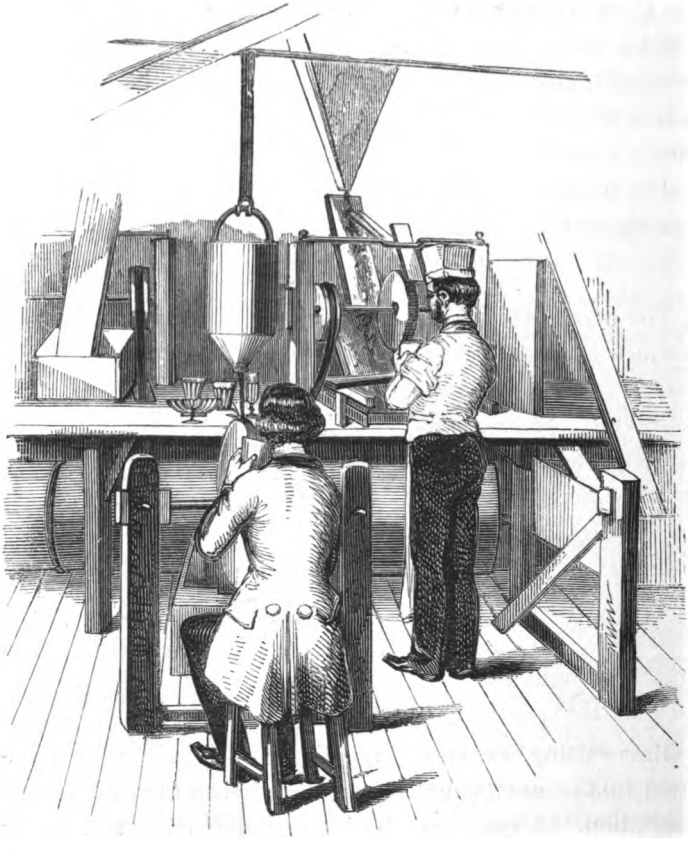


Drop Pinching.

GLASS-CUTTING.

Glass-cutting, or, more properly Glass grinding, as illustrated in the next page, is too well known to need minute description. A cast-iron wheel has sand and water dropping from the hopper, while revolving in a lathe propelled by steam power; the friction of the grit of the sand, reduces to its required form the Glass placed beneath it. A stone wheel with water smoothes out the rough sand marks, and prepares

it for the polishing, which is effected by means of a willow wood wheel, first with a mixture of pummice and rotten stone, and finished by the same wood wheel, or lap, with putty-powder.*



Glass Cutting, as practised in factories where steam power is used; the drum, P, being connected by a strap to the engine, and communicating the power to the smaller gear

* A preparation of tin and lead.

All table Glass ware and hollow articles are thus cut; chandelier drops are also similarly cut, with iron and stone wheels, except the polishing, which is done with a lead wheel, or lap, supplied with a little very fine rotten-stone and water. The sides of the lead lap are occasionally roughed, or notched, like a file, to enable its recesses to hold the above. When the sides become smooth by use, they must be re-notched, like millstones for grinding flour.

The steam-engine has almost excluded hand labour for turning cutters' lathes.

GLASS ENGRAVING.

The period when the art of engraving Glass borders and arabesques was first practised, cannot be satisfactorily ascertained. Intaglio and cameo figure engraving, upon real and artificial stone, is known to have been employed by the Greeks and Romans at a very early period, (prior to the Christian era;) their artists wrought and studied in the purest and highest range of statuary engraving; and it is probable that the bas-relief figures on the Portland and Naples Vases were engraved at the lathe by

Glass Engraving.

these artists. The Venetians are not supposed to have cultivated the art of engraving rough ground with polished relief on Glass, which is now, and has been, for perhaps two centuries, so successfully pursued by the Bohemians. Their excellent arabesque borders, animals, and landscapes, are executed in quantities, with surprising rapidity, and at a low rate of wages; from ten to fifteen shillings a-week being in Bohemia a fair remuneration even for a tolerably artistic engraver, who would earn fifty shillings a-week if working in London.

Copper wheels, and finely pulverized emery mixed with oil, are used to execute the outline and ground of the modern engraver's work; and for the polished work, lead wheels, and very finely pulverized emery, are employed.* The most elaborate and splendidly executed artistic specimen of engraving, is now at the Falcon Glass works, and is the work of a German artist, who devoted several years to its accurate details. The subject is from the picture of Lebrun, representing the final battle and triumph of Alexander the Great over Darius, which ended in the entire overthrow of the Persian empire.

Coarse patterns for hall lamps are engraved by the Glass-cutter's smoothing wheel. The contrast of the polish of a wood wheel upon a ground roughed by sand is often effective, though the range of pattern is somewhat curtailed by the large size of the cutter's wheels, rendering it difficult to execute curvilinear designs. The Venetians practised a curious art of engraving with the point of a diamond, or broken steel file. This

* Stoppering, (bottles,) like engraving, requires little power, but that the velocity be varied; hence, the foot lathe answers as well as, or better than, steam power.

simple process was, no doubt, employed anterior to engraving by the lathe; to this it probably gave way, as the accurate artistic effects of the lathe far surpass the crude work of steel or diamond etching. Etching by fluoric acid has been introduced, but its bite is not sufficiently rough, and is not found effective for general purposes. Pleasing effects are produced by engraving through an outer casing of coloured Glass into an interior white, transparent, or enamelled Glass, usually afterwards decorated with gold, and painted in arabesques, or other patterns. This work is chiefly the produce of Bohemia, Bavaria, and France: it has recently been executed at the Falcon Glass Works with success, in engraved classical designs.

GLASS STOPPERING.

Stoppering is usually done within Flint Glass premises. The lathe is similar to that employed by Glass engravers, being what is termed a mandril tool. The mouths of the bottles are opened by a steel projecting cone, or mandril, to the required size to suit the stopper; and emery powder and water being applied, the rotating friction soon effects its object. The stopper must be fixed in a wooden chuck, and rotated by the lathe, to be first reduced to the dimensions of the mouth of the bottle, by emery and water; and finally introduced into it, carefully grinding the one into the other, reducing the speed, and supplying by degrees finer and finer emery (and water), until the stoppering by the lathe is completed; a few turns of the stopper with the hand follow to finish.

GENERAL OBSERVATIONS.

To an observant eye, the working movements of the Flint Glass-blower are performed with ease and elegance, perfectly natural. In modern Glass-houses, which convey the smoke instantly upward, without its descending into the houses to affect blowers' lungs, the employment is by no means injurious to health. In the exercise of walking, swinging, and shaping, and in almost all the manipulations of the factory, every limb and muscle is brought into healthful movement; and it is found that even the exertion of the lungs in blowing is by no means unfavourable to longevity. Much improvement has, within the last few years, taken place in the temperance and morals of the workmen. Rheumatism and gout, which formerly prevailed among the men in Glass-works, are not, at present, more frequent than the average experience of what may be considered the most healthful manufacturing employments in large towns.

In making new shapes in Glass, much is left to the judgment of the workman, who reasons and reflects on the best mode of arriving at certain results, by avoiding tool-marks, in forming, re-shaping, &c., by which time will be saved, and the product less disfigured. Many visitors have been struck by the beauty of outline so frequently developed in blowing and forming Glass vessels in their onward progress; which, although it cannot be arrested in its rapid transition from one form to another, often suggests new ideas or the invention of new designs. Occasionally, in flashing, or in modifications of the flashing process, the changes of form seem almost miraculous, and rather to be

deserving of the term "creation" than that of "manipulation." Many workmen never rise higher than the first or second grade; and those who have taken the highest rank have shown very early precocity. Boys commence as takers-in at about eight years of age, and advance to the highest grade by degrees, if clever or industrious. Unless they have learned to read and write before that period, (their evenings being employed in the factory on the first four days of the week,) it is only on the Sunday and the latter part of the week that they can devote any time to mental improvement. A school on the premises, for instruction on Fridays and Saturdays, is a great desideratum for the boys as well as men, who wish thus to employ a portion of their leisure time; and the expense to proprietors would be amply repaid by the subsequent gratitude, and improved intelligence and conduct of their workmen.

Perhaps, there is no employment so much dependent upon steadiness of nerve, self-possession, and skilful manipulation, as Glass-making. It requires adroit adaptations of the simplest tools, for the rapid production of manifold forms and designs, upon the most pliant of material, while it retains its heat; and perfection depends not altogether upon long-continued practice, but upon a certain innate tact, without which no workman can ever rise to eminence. There can scarcely be, chemically, and in reference to the preparation of the crude materials, a manufacture of greater simplicity or of easier management than Flint Glass; but, like the delicate machinery of the watch, or the skilful management of a musical instrument, no small practical experience is needed to keep everything in time and tune, and in its place, for working out the harmonious arrangements of the whole, and

for bringing to perfection a manufacture, which, in the aggregate, produces employment for a large number of workmen, at a comparatively small cost of crude material.

To conclude: the invention of Glass-making has not been more beautifully illustrated than in the following reflections, of philosophical eloquence, from the pen of Dr. Johnson:—

"It might contribute to dispose us to a kinder regard for the labours of one another, if we were to consider from what unpromising beginnings the most useful productions of art have probably arisen. Who, when he first saw the sand or ashes, by a casual intenseness of heat, melted into a metalline form, rugged with excrescences and clouded with impurities, would have imagined that, in this shapeless lump, lay concealed so many conveniences of life as would, in time, constitute a great part of the happiness of the world? Yet, by some such fortuitous liquefaction was mankind taught to procure a body, at once, in a high degree, solid and transparent; which might admit the light of the sun, and exclude the violence of the wind; which might extend the sight of the philosopher to new ranges of existence, and charm him, at one time, with the unbounded extent of material creation, and at another, with the endless subordination of animal life; and, what is of yet more importance, might supply the decays of nature, and succour old age with subsidiary sight. Thus was the first artificer in Glass employed, though without his knowledge or expectation. He was facilitating and prolonging the enjoyment of light, enlarging the avenues of science, and conferring the highest and most lasting pleasures; he was enabling the student to contemplate nature, and the beauty to behold herself."

EXPLANATION OF THE COLOURED PLATES.

PLATE I.

NAPLES VASE.—(*Frontispiece.*)

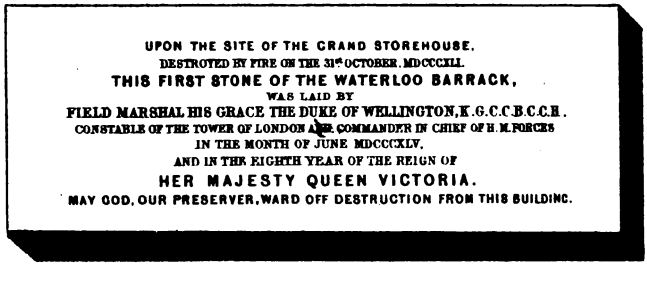
THE drawing of the Naples (or Pompeii) vase, is half the size of the original, deposited in the Public Museum at Naples. It was discovered in a sepulchre of Pompeii, on the 29th of December, 1839. It is of the same character, in the colours and quality of the Glass, as the Portland vase, in the British Museum; the white enamel figures upon the dark blue transparent ground being raised, or embossed out of the white exterior coating, by first-rate engravers, probably Grecian artists working in Rome at an early period, or possibly as late as the reign of Trajan, about seventy years after the Christian era.

This beautiful vase is, no doubt, of more recent date than the Portland, and has an artistic playfulness of subject, of less severe and conventional character. It is tastefully descriptive of the in-gathering of the vintage harvest; beautifully harmonizing the Bacchanalian figures with the arabesque

scrolls. The design and execution are only surpassed by the Portland vase, which Zähn, in his beautiful work, entitled "Ornamentum zu Pompeii," admits to be superior. The form is entirely dissimilar to the Portland vase, although perhaps not less elegant. The foot of the Naples vase has been abstracted by some sacrilegious hands. Zähn supposes it to have been of gold. With this exception, the body of the vase, handles, &c., indeed, the whole, is perfect; and affords a practical and instructive illustration of the great artistic skill attained and the time bestowed by the ancients upon this extraordinary class of productions. It is somewhat unusual, as in the case of this vase, to find the chief subjects—viz., the Bacchanalian figures —placed under each of the handles, instead of between the handles. Who is to say that the great Phidias, or his pupils, might not have condescended to work upon such magnificent gems of art?

By reference to the illustrated manipulatory portion of this work, full explanation will be found of the mode of casing, or placing two or more coats of glass upon each other; a degree of perfection of the art at that early period, of which the Naples and Portland vases, and that found a few years since at Pompeii, and drawn by Minutoli, (a portion of which is in possession of Mr. Richardson Aldjo, and the remainder in the British Museum,) are splendid specimens. They are indicative of great Glass-making skill, especially the handles, which are shaped with admirable taste and accuracy; and we are at a loss which most to admire—the beauty of the form, or the skill and patience of the engraver.

Ancient Glass found in Egyptian Tombs, at Thebes.


UPON THE SITE OF THE GRAND STOREHOUSE,
DESTROYED BY FIRE ON THE 31st OCTOBER, MDCCCXII.
THIS FIRST STONE OF THE WATERLOO BARRACK,
WAS LAID BY
FIELD MARSHAL HIS GRACE THE DUKE OF WELLINGTON, K.G.C.C.B.C.C.H.
CONSTABLE OF THE TOWER OF LONDON AND COMMANDER IN CHIEF OF H.M.FORCES
IN THE MONTH OF JUNE MDCCCXLV,
AND IN THE EIGHTH YEAR OF THE REIGN OF
HER MAJESTY QUEEN VICTORIA.
MAY GOD, OUR PRESERVER, WARD OFF DESTRUCTION FROM THIS BUILDING.

Glass Brick in foundation stone at the Tower of London.

PLATE II.

THEBES FRAGMENTS.

The specimens drawn in this Plate were brought by Mr. Bankes from the Egyptian tombs at Thebes, about twenty-five years since, and were placed in the hands of the author.

They are drawn the exact sizes and colours of the originals; and their great variety of subjects portrays the chemical and inventive powers of the ancients. The colours are rich of their kinds, and show considerable knowledge of vitreous colouring; they are, no doubt, the produce of the earliest of the Egyptian manufactories. It is said the great Hermes taught the Glassmakers of Egypt this ingenious art.

Fig. 1. Is a fragment of Glass, which, when discovered, appeared to be one piece only; but proved, upon closer inspection, to be in two pieces, adhering to each other by a bituminous cement. The variegated portion consists of well-contrasted, brilliantly-coloured devices of blue, green, red, and yellow; and this being attached to an adhering piece of more subdued colours, forms a lateral continuous border, giving to the whole a finished margin: it was probably used for ornamenting an ancient bath. The pattern and colours are the same on both sides; the front only was flattened and polished, the reverse was irregular in surface, and was, therefore, better calculated to adhere to the cement, which not only fastened the two pieces together, but fixed them to the walls which they decorated. In this fragment, very

little decomposition is apparent on the upper surface; and under the cement, no decomposition whatever has taken place.

Fig. 2. Has the same variety of colours as the above, but with a regularly foliated rosette-like design, in yellow, red, and white, upon a dark blue ground. This has a mosaic granular appearance, and shows its pattern in front and reverse, in an oblique direction. The acute angular fracture on the edge, exhibits a partial section of the pattern and colours, and leaves no doubt of the whole being formed by threads of coloured Glasses, fused together in masses and veneered, by cutting through at right angles, or obliquely, as more fully explained in the manipulatory portion of this work.

Fig. 3. This fragment, a miniature effigy of the Egyptian idol Isis, appears to have been pressed into a metal mould while the Glass was soft. The colour was of the richest azure blue, tolerably transparent. (See Klaproth's analysis, which defines its chemical constituents; the colouring oxide was, no doubt, iron.) This specimen, the production of Alexandrian, or very ancient, furnaces, was most probably suspended about the person of its owner by the perforated loop at the top, and worn as an amulet.

Fig. 4. A small lachrymatory vase, of the same rich azure blue as the Isis fragment; the handle and mouth of the vessel are crudely formed, and the white enamel on its body is welded to the blue, and may have had some hieroglyphical meaning. It is as perfect as originally manufactured, with the exception of a very slight decomposition of surface.

Fig. 5. Fragment of an Ethiopian effigy, or statuette, of a clear amber colour. Its colouring constituent was probably iron, in a different proportion of oxygen to that of the azure blue.

Fig. 6. Fragment of black pipe beads, intermixed with a pattern of white enamel.

Figs. 8 to 15. Eight beads, decidedly some of the Aggry beads so well described by Bowditch, and quoted in the Historical Notices of this work. (See page 10.) These have never been imitated by the Venetians, who mentioned to Mr. Bankes that they were unacquainted with the mode of making them. With some practice they could, no doubt, be successfully imitated.

Figs. 16 to 19. Specimens of ancient glass coins with inscriptions. 17 and 19 are partially opalized by phosphate of lime (bones.) 18. The red is the effect of copper and iron, and the blue, Fig. 16, of iron. (See Klaproth's analysis, page 76.)

Fig. 21. Is a specimen of modern incrusted inscription: the letters are drawn upon a piece of glass with a vitrified black paint, and burnt in: it is introduced while at nearly a red heat, into a glass pocket, as more particularly explained in the third portion of this work, elucidatory of the introduction of cameo figures into Glass. (See page 120.) The following is a copy of the inscription, which was incrusted at the Falcon Glass Works:—

UPON THE SITE OF THE GRAND STOREHOUSE,
DESTROYED BY FIRE ON THE 31ST OCTOBER, MDCCCXLI.
THE FIRST STONE OF THE WATERLOO BARRACK
WAS LAID BY
FIELD MARSHAL HIS GRACE THE DUKE OF WELLINGTON,
K.G., G.C.B., G.C.H.,
CONSTABLE OF THE TOWER OF LONDON, AND COMMANDER-IN-CHIEF OF H.M. FORCES,
IN THE MONTH OF JUNE, MDCCCXLV.
AND IN THE EIGHTH YEAR OF THE REIGN OF
HER MAJESTY QUEEN VICTORIA,
MAY GOD, OUR PRESERVER, WARD OFF DESTRUCTION FROM THIS BUILDING.

PLATE III.

ROMAN FRAGMENTS.

Fig. 1. An ancient Roman fragment of Glass of the smeltz character. It was exhumed in the city of London, near Moorfields, and is now possessed by Mr. Roach Smith: it is a melange of yellowish-white enamel, with a very dark iron red. Specific gravity, 2576.

Fig. 2. Has the projecting Roman pillars, as described in the manipulatory portion of this work, (see page 104;) and, like most of the Compound Glasses, has scarcely undergone any decomposition whatever. Specific gravity, 2483. Also Mr. R. Smith's.

Fig. 3. Is a very rare specimen from Mr. R. Smith's collection, and displays the great perfection of ancient Glass cutting. It formed part of an elegant drinking-cup. One peculiarity is, its lightness; it being but little more than twice its weight of water—viz., of a specific gravity 2049. It is quite colourless.

The ancients had their White Glasses both of simple and compound character; the latter were by far the most conservative. Specimens of the former, in the British Museum, and in private hands, are in a state of considerable decomposition. The heat of the burning lava which overwhelmed the devoted cities of Herculaneum and Pompeii, may have had great effect in destroying part of the alkaline properties, (much greater than the ordinary influence of the atmospheric air,) and thus causing, in the partial decomposition, the

ANCIENT GLASS.

1 . 2 . 3 . 4 . Roman Fragments.
5 . 6 . 7 . 8 . 9 . 10 . Ancient Fragments in the British Museum.

R. Jobbins

John Strudwick. del

exterior coating to become opaque, and peel off film by film, and layer by layer, in siliceous opalescent matter, sometimes in iridescent tints, until the whole mass had become reduced materially in weight; leaving part of the interior only, of a transparent substance, comparatively porous and weakened in structure by the loss of alkali.

Dr. Faraday, who kindly examined a piece of this fragment, proved that it softened by the blow-pipe, and took the impression of a file. He found no trace of lead, and but little lime; and the chief part of the alkali was considered potash. No doubt, therefore, exists of its being ancient Glass. The large quantity of alkali in comparison with the sand causes its peculiar lightness; its excess together with caloric has induced exudation, roughness of surface, and the dislocation of some of its particles; it having throughout small cracks, as if caused not by friction but by the loss of the cementing properties of its alkali.

Another fragment of Glass, considered equally ancient (by Mr. Roach Smith) as the former, is of a greenish tint; it has, no doubt, iron in its constituents; and, from its compound character, is as perfect as at the hour it was manufactured. Its specific gravity is 2600. It has small projecting solid lumps at regular distances from each other, intended for ornament.

A third fragment is of blown diamond pattern of heavy Glass: it has a slight white coating or film, which yields to, and can be removed by, the nail; is otherwise perfectly colourless and transparent, and about the same specific gravity as modern Flint Glass—viz., 3144. It has a polished surface, and is in excellent preservation.

The two latter fragments being in so high a state of preservation would lead to the conclusion that their conservative

properties are due to the presence of metallic oxide in connexion with silex, and therefore requiring a less proportion of alkali.

Of this character of artificial crystal, the author has seen an ancient drinking-glass, of a Medicean form, on a foot of considerable substance, and nearly entire, the property of a tourist, who procured it from the neighbourhood of Rome. It is remarkably heavy, and appears as if it had been shaped all over at the cutting lathe, so as to raise rings out of the exterior of the solid Glass, they were certainly not welded on in the ordinary manner while hot; and the vessel has the appearance of having been blown in an open-and-shut mould, like the modern Bohemian Glasses, and the rim afterwards cut off and polished. Although no opportunity has been afforded of taking its specific gravity, it appears much heavier than modern Flint Glass, and slightly yellow in tint. It is clear, therefore, that the ancients had not only the art of colouring Glass, and of using lead in these imitations of the precious stones, but they had (at what precise period in history is unknown) likewise the knowledge of the use of lead, and perhaps barytes, to give to white Glass density and refractive beauty. In truth, the more a manufacturer gets acquainted with ancient fragments, the more firmly he appreciates the high state of perfection to which ancient workers in Glass carried their interesting art, but of which skill we find few records in ancient literature.

Fig. 4. Part of an ancient handle of the specific gravity, 2500. Its green tint is indicative of the presence of iron. It is in a high state of preservation owing to the conservative tendency of the iron which forms one of the constituents. The workmanship is ingenious.

Venetian
Frosted Glass.

Figs. 5, 6, 7, 8. Are specimens in the British Museum of the delicate and beautiful mosaic pictures worn, probably, as rings or brooches, when mounted in gold, by the ancients.

Fig. 9. The formation of this pattern differs from the mosaic; and it is somewhat difficult to imagine the manipulations of the Glass-maker in working out its peculiar design.

Fig. 10. Curious specimen of ancient cased Glass, of the same class as the Portland vase, also from the British Museum.

PLATE IV.

ANCIENT VENETIAN SPECIMENS.

Fig. 1. Ancient Venetian cup and cover, called Vitro di Trino. This specimen was purchased about the year 1836, at the sale of the collection of Lady Bagot. The position of the entrapped air-bubbles varies, when the mass is stretched out of its original structure, they are upon the diamond crossings of the white enamel threads, as fig. 3; although, usually, between the junction of the angles, as fig. 4. The foot is made by a ring neatly cast upon the bottom of the cup, within which all the white enamel lines concentrate to the centre, with the accuracy of lathe or engine turning.

Fig. 2. Ancient Venetian frosted vase; formerly the property of Lady Bagot, subsequently of the author. The satyr heads have been impressed by a seal or die, after the vase was frosted, the gilding of which, as well as the border or rim, has been fixed by burning. The frosting manipulation and the Vitro di Trino are explained at pages 113 and 114.

PLATE V.

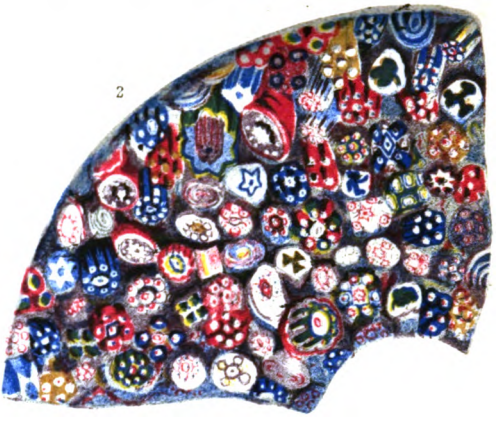
GRECIAN AND MISCELLANEOUS SPECIMENS.

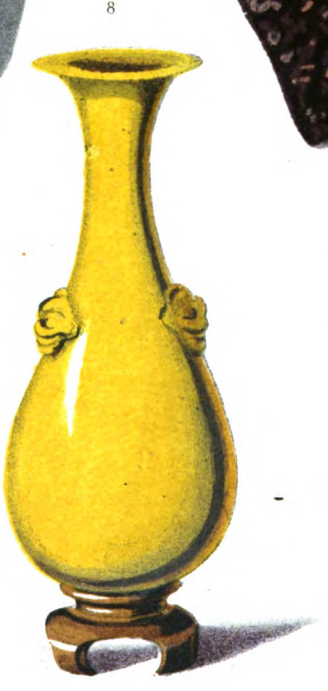
Fig. 1. This fragment, in the possession of W. R. Hamilton, Esq., seems to be the *ne plus ultra* of the chemical and manipulatory power of the ancient Glass-maker. It consists of no fewer than five layers or strata of Glass, originally forming a portion of a vase. The interior layer is the usual blue, sapphire colour; and the green and red coatings are similar to those analysed by Klaproth. The colours of the numerous strata (see the section) are separated from and contrasted with each other by layers of white enamel, skilfully arranged by some eminent artist of the school of Greece, for the embossment of his cameo subject, as well as for blending them into each other artistically. The subject—a female reposing upon a settee—is executed in the very highest style of art, and is a fine specimen of gem engraving. The drawing is the size of the fragment.

Fig. 2. A Patera of ancient Grecian or Roman Glass, decorated with the moulded Roman pillar, of light green tint, but slightly opalescent, and iridescent through decomposition of surface. It is in the London Polytechnic Institution, and was found in a tomb, in one of the Grecian islands.

Figs. 3 and 4 are green Osorian vases in the British Museum. The largest is about fifteen inches high, in excellent preservation; and both are beautiful specimens of the art,—especially the handles, which show the perfection of the ancients in the art of Glass-making. The material is common, and resembles

1. Ancient Mosaic.
2. Antique Glass Vase.
3. Roman Vase.
4. Roman Vase.
5. Chinese Lion.





1. Venetian Ball.
2. Millefiore.
3. 4. 5. Roman Fragments.

6. Artificial Sardonyx.
7. Roman Mosaic Gem.
8. Chinese Glass.

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our ordinary Crown Glass. These large pieces required correspondingly large crucibles and furnaces for their formation; but whether they are of Roman or earlier manufacture, it is difficult to decide.

Fig. 5, the Chinese lion, is cut by the engraver's tool from a solid pedestal of Glass, of great density; probably, made from broken English Flint Glass, with an addition of oxide of lead. The execution, as a work of art, is by no means pleasing, but as a piece of ingenuity and uncommon industry it is a curiosity: it may be seen at the Museum of Geology, at Charing Cross, at the head of which institution is Sir H. de la Beche, to whose kindness the author is much indebted.

Fig. 6. A small glass rosette, brought from China, in the collection of the Propaganda at Rome.

Fig. 7. A small green glass lion, exhumed at Tivoli.

These specimens are sketched from Minutoli's work, and serve to show the variety of countries whence fragments of ancient glass have been discovered.

PLATE VI.

ANCIENT MOSAIC, CHINESE, AND VENETIAN SPECIMENS, ETC.

Fig. 1. A solid ancient Venetian ball, consisting of fragments of filigree cane, placed in a hollow, transparent, white Glass pocket, and collapsed by extracting the air as the mass fuses together by the heat of the furnace.

Fig. 2. Specimen of modern French Mille-Fiore Glass,—formerly made by the ancients and the Venetians: it consists of slices off the ends of cones, of various colours, inclosed in

white transparent glass, as described in the manipulatory portion of the work. (See page 110.)

Figs. 3, 4, and 5. Ancient Glass, in the possession of Mr. Roach Smith. These varieties are produced by mixing small Glass bugles or beads with masses of fused green, purple, or azure-blue glass. They are curious and interesting, and in excellent preservation.

Fig. 6. Crude artificial sardonyx—from the British Museum—of three layers of opaque coloured Glass: this, it is supposed, was manufactured for the Grecian artists at Rome, for the purpose of cameo-engraving, or for cutting into other gems of high art, and no doubt afterwards suggested larger gems and vessels, such as the Portland and other vases; also the vase described by Minutoli (the neck and handle of which are in the cabinet of Mr. Richardson Aldjo, and the remainder in the British Museum); likewise the Naples or Pompeii vase. (See Plate 1.)

Fig. 7. Fragment of Mosaic Glass, which, as well as fig. 6 in the British Museum, is a beautiful exemplification of the art of making pictures of Glass, with variously-coloured threads of Glass fused together, as described by Wincklemann and others; by means of which, elegant arabesque designs were executed by the ancients.

Fig. 8. Specimen of Chinese Glass, in the possession of the author. The constituent of the yellow colour is unknown. The Glass is supposed to be chiefly composed of felspar; the heads are impressed by metal dies. The foot is of wood.

VIGNETTE IN TITLE-PAGE.

THE Portland, Alexandrian, Naples, and Aldjo Vases.

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